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Aggregate Report AR85-2

Late Wisconsinan Stratigraphy and Sand and Gravel Resources in the Rural Municipality of Lac du Bonnet and Local Government District of Alexander

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TABLE OF CONTENTS

Page

Abstract ... ii

Introduction ... 3
- Location and Access ... 3
- Physiography ... 3
- Methodology ... 3
- Previous Work ... 3
- Acknowledgements ... 4

Bedrock Geology ... 6

Stratigraphy of the Belair and Milner Ridge Moraines ... 7
- Introduction ... 7
- Description of Units ... 7
  - Lower till ... 7
  - Interlobate moraine sediments ... 7
  - Whiteshell till ... 9
  - Calcareous till ... 9
  - Subaqueous fan sediments ... 9
  - Postglacial sediments ... 18

Late Wisconsinan History ... 20

Sand and Gravel Resources ... 25

References ... 26

Appendix A: Sample lithology data ... 28

Appendix B: Description of aggregate deposits ... 31

Appendix C: Grain size data of aggregate deposits ... 37

Appendix D: Example of computer printout information ... 44

FIGURES

Figure 1: Location map of area west of Winnipeg River ... 2

Figure 2: Cross-sections showing morphology of Belair and Milner Ridge moraines ... 4

Figure 3: Composite stratigraphic section of the Belair and Milner Ridge moraines; modified from Matile and Groom (1983) ... 7

Figure 4: Histograms showing the grain size distribution of the Winnipeg Formation sandstone, the sand facies of the interlobate moraine sediments, the Whiteshell till and the calcareous till ... 8

Figure 5: Clast lithology of the stratigraphic units of the Belair and Milner Ridge moraines ... 10

Figure 6: Ternary diagram showing matrix texture of the till units ... 11

Figure 7: Glacial thrusting of calcareous till into underlying rhythmically bedded interlobate sediments ... 11

Figure 8: Diagram comparing texture and lithology of calcareous till samples from the study area with the three calcareous till formations described by Teller and Fenton (1980) ... 12

Figure 9: Subaqueous fan deposit, showing inner fan and channelized outer fan ... 13

Figure 10: Massive gravel of the inner fan facies, Seddons Corner deposit ... 14

Figure 11: Gravel of the inner fan facies, Gull Lake pit ... 14

Figure 12: Large scale crossbedding in distal portion of inner fan, Gull Lake pit ... 15

Figure 13: Maximum grain size along the length of gravel-filled channel in outer fan ... 15

Figure 14: Depositional model of subaqueous fan ... 16

Page

Figure 15: Subaqueous fan deposits during the regression of Lake Agassiz. . . . 17
Figure 16: Lake Agassiz beach deposit overlying subaqueous fan gravel. . . . 18
Figure 17: Morphology of ice-push ridge. . . . 19
Figure 18: Isopach diagram of ice-push ridge. . . . 20
Figure 19: Depositional model of interlobate moraine. . . . 22
Figure 20: Ice marginal positions during the Late Wisconsinan. . . . 23
Figure 21: Reconstruction of four major levels of Lake Agassiz. . . . 24
Figure C-1: Grain size classification 37

TABLES

Table 1: Estimated reserves and demand for sand and gravel. . . . 25
Table A-1: Lithology of the 4-16 mm pebble fraction of all samples. . . . 28
Table B-I: Aggregate deposits in the R.M. of Lac du Bonnet. . . . 31
Table B-2: Aggregate deposits in the L.G.D. of Alexander. . . . 34
Table B-3: Aggregate deposits in the R.M. of St. Clements (eastern portion). . . . 36
Table C-I: Grain size distribution of aggregate samples in the R.M. of Lac du Bonnet. . . . 38
Table C-2: Grain size distribution of aggregate samples in the L.G.D. of Alexander. . . . 40
Table C-3: Grain size distribution of aggregate samples in the R.M. of St. Clements. . . . 43

MAPS

Map AR85-2-I: Quaternary Geology in the R.M. of Lac du Bonnet . . . . in pocket
Map AR85-2-2:Quaternary Geology in the L.G.D. of Alexander. . . . in pocket
Map AR85-2-3:Aggregate Resources in the R.M. of Lac du Bonnet . . . . in pocket
Map AR85-2-4:Aggregate Resources in the L.G.D. of Alexander . . . . in pocket

ABSTRACT

The stratigraphy of the Belair and Milner Ridge moraines was examined during the course of an aggregate resource inventory carried out in the R.M. of Lac du Bonnet and the L.G.D. of Alexander. Sediments within the moraines include an interlobate sand facies, three till units, and sand and gravel of subaqueous fan origin. Lake Agassiz sediments overlie the moraine sediments.

The sand and gravel resources of the area are found in glaciofluvial and glaciolacustrine deposits located primarily west of Winnipeg River (Maps AR85-2-1 to 4; scale 1:50 000). Gravel reserves are estimated at 24.5 million m^3 and demand over the next twenty-five years is estimated at 9.1 million m^3. However, there is a scarcity of gravel deposits east of Winnipeg River and bedrock quarries are an important source of aggregate for that region.

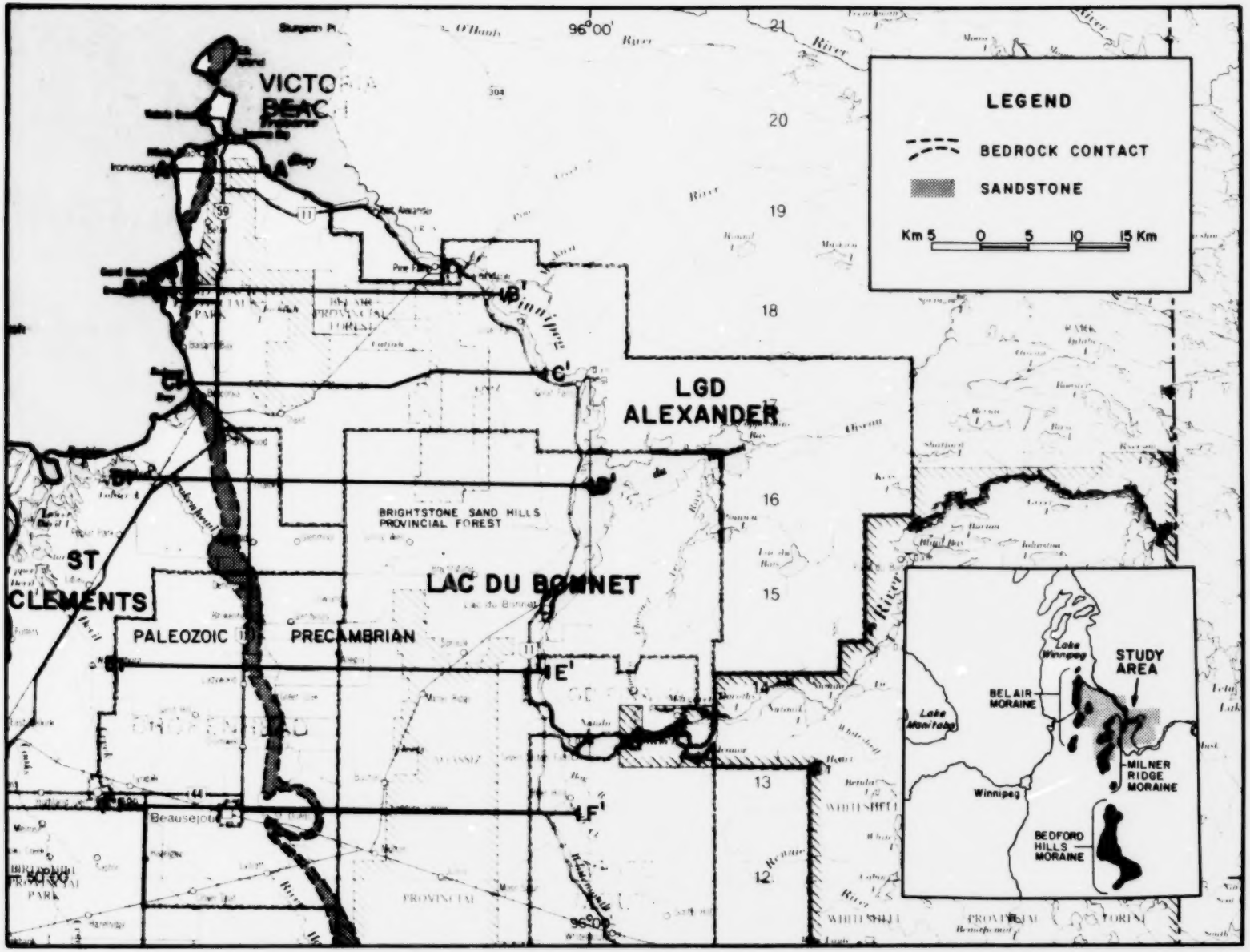


FIGURE 1: Location map of area west of Winnipeg River showing Paleozoic/Precambrian contact, location of topographic cross-sections and locations of moraines.

INTRODUCTION

LOCATION AND ACCESS

The Rural Municipality of Lac du Bonnet and the Local Government District of Alexander cover 2800 km² in southeastern Manitoba between Twps. 13 and 19 and Rges. 7E and 14E. The study area was extended westward to include an unmapped portion of the Rural Municipality of St. Clements (Fig. 1). The area east of Winnipeg River was previously mapped by the Mines Branch at a scale of 1:100 000 (E. Nielsen, 1986) and was not reassessed during this project.

The study area, lying west of Winnipeg River, is primarily a farming district although there has been extensive cottage and recreational development along the shores of Lake Winnipeg and Traverse Bay. As well, the Belair and part of the Agassiz Provincial Forests are located within the area. The result is an extensive network of paved highways, gravelled section roads and forestry trails that give good access to most areas.

The villages of Lac du Bonnet and Pine Falls are the major service centres for the districts.

PHYSIOGRAPHY

There are two major physiographic regions in the area — the Canadian Shield in the east and the Manitoba Lowland in the west (Bird, #1972).

Overall, the land has a gentle northwest slope, falling from 275 m above sea level in the southeast to 217 m a.s.l. along the shore of Lake Winnipeg. Local relief on the Shield is less than 5 m and drainage is poor. The area is characterized by rock outcrop with intervening swamp deposits. Relief on the Manitoba Lowland is very low and drainage is also poor. The area is characterized by clay plains, in places overlain by swamp and peat deposits.

The major exception to this generally flat terrain is in the area of the Belair and Milner Ridge moraines. The moraines are broad, discontinuous ridges that rise 30 to 50 m above the surrounding plain (Fig. 2). The moraines are formed predominantly of sand and were greatly modified during the regression of Lake Agassiz. Beach ridges, spits and wave-cut scarps are common. Lake terraces are well developed, particularly at the northern end of the Brightstone Sand Hills. Sand dunes up to 3 m high are found in places throughout the moraines.

METHODOLOGY

Potential aggregate deposits were first delineated on 1:50 000 scale airphotos. Airphoto interpretation incorporated information from pit inventory files of the Department of Highways and Transportation Services and from soil maps (Smith and Erlich, 1967).

During field mapping, all gravel pits were visited and samples collected from deposits considered to be of economic value. This was followed by a backhoe program designed to determine depth and extent of aggregate deposits. Backhoeing in the R.M. of Lac du Bonnet was carried out in conjunction with the Materials and Research Branch of the Manitoba Department of Highways and Transportation; 773 holes were dug of which 442 were sampled for sand and gravel. Backhoe test pits averaged 4 m in depth. Stratigraphic samples of till and sand deposits were also taken during the course of the study.

Gravel samples weighed between 15 and 20 kg; maximum grain size sampled was 76 mm. The samples were sieved at the size intervals shown in Figure C-1. Till samples weighed between 5 and 10 kg. The grain size distributions of the samples were determined by sieve and pipette analysis following the method outlined by Folk (1974). The samples were analysed at 1 phi intervals from -6 phi to 8 phi. The clay fraction (less than 8 phi) was not subdivided. Glaciofluvial, glaciolacustrine and eolian sand samples were dry sieved at 1 phi intervals.

A petrographic examination of the 4-16 mm size fraction of all gravel and till samples was carried out. The pebbles were divided into carbonate and Precambrian lithologies.

Field data and gravel deposits were plotted on 1:15 840 scale airphotos and these were used to produce the 1:50 000 scale maps accompanying this report. Aggregate reserves were calculated on a quarter section basis, taking into account proven depths and the amount of depletion and sterilization.

Sample grain size data and detailed information for each aggregate deposit are available through the Aggregate Resources Section. An example of the computer printout for each deposit and sample is given in Appendix D.

Lake Agassiz levels, were obtained by transferring the mapped beach deposits onto 1:50 000 topographic maps and interpolating their elevations.

PREVIOUS WORK

The R.M. of Lac du Bonnet and the L.G.D. of Alexander have been discussed in several regional studies from as early as 1890, when Upham identified the eastern limit of carbonate erratics as a line trending southeast from Lake Winnipeg to Lake of the Woods. He noted this line as the eastern extent of "glacial currents that moved south-southeast in the vicinity of Winnipeg" (Upham, 1890, p. 30). Johnston (1923) mapped the surficial deposits of southeastern Manitoba; he identified several beach ridges in the area and described the Belair moraine as a "marginal deposit of an ice sheet". Smith and Ehrlich (1967) mapped surface deposits as part of a regional soil study, and described the Belair and Milner Ridge moraines as end moraines.

McPherson (1970) conducted a detailed study of the Quaternary geology of the area. In his reconstruction of Late Wisconsinan glacial history, he postulated two major ice advances. The first, from the northeast, deposited the Precambrian-rich Belair drift. The Belair and Milner Ridge moraines were deposited as end moraines during the retreat of this ice. The second advance, from the northwest, overrode the entire area depositing the calcareous Libau drift. Lake Agassiz formed as this ice retreated from the area.

Lebedin and Pollock (1978) adopted McPherson's stratigraphy when constructing cross-sections through the area as part of a groundwater study. Their cross-sections are based on water-well records and drillhole data.

Fenton (1974), working immediately south of the study area, also postulated two major ice advances. Ice from the northeast deposited the Precambrian-rich Senkiw Formation. He stated that the Bedford Hills moraine, which he correlated with the Belair and Milner Ridge moraines north of his area, was deposited in an ice-walled channel during the retreat of this ice. The next advance came from the northwest, depositing the calcareous Roseau Formation during the Late Wisconsinan. The Roseau ice readvanced at least twice during its overall retreat from the area.

Teller and Fenton (1980) examined over a thousand samples of Late Wisconsinan tills in southeastern Manitoba, including the present study area. In their reconstruction of Late Wisconsinan glacial history,

the first ice to advance over the area came from the northeast depositing the Precambrian-rich Senkiw Formation and its eastern lateral equivalent, the Whiteshell Formation. As this ice retreated, ice from the northwest advanced into the area, depositing the calcareous Roseau Formation. The Belair and Milner Ridge moraines were deposited as interlobate moraines at the junction of these two ice masses before being overridden by the Roseau ice as it expanded to flow south into the United States. Retreat of the Roseau ice was followed by the formation of Lake Agassiz into which the ice readvanced twice. The first advance deposited the Whitemouth Lake Formation; the second deposited the Marchand Formation.

Nielsen and Matile (1982) used McPherson's nomenclature to describe drift deposits exposed at several sites in the area. An interlobate origin was also postulated for the Belair and Milner Ridge moraines, following Teller and Fenton (1980).

Elson (1983) gave a comprehensive review of Lake Agassiz studies since their inception in 1823. Fenton et al. (1983) presented a detailed history of the southern Lake Agassiz basin. Their chronology is based on wood dates and places the beginning of the lake at about 11 500 years BP. In southern Manitoba, the lake went through four phases. During the earliest phase, the Lockhart, the highest Lake Agassiz beaches formed and the lake drained southward through the Mississippi River system into the Gulf of Mexico. Ice retreat opened lower outlets in northwestern Ontario marking the beginning of the low-water Moorhead Phase. Lake levels fell to at least the Ojata strandline, leaving much of the south basin dry, as Lake Agassiz drained eastward into Lake Superior. Advancing ice, about 9900 BP, blocked the eastern outlets causing the lake to rise to the Campbell level during the Emerson Phase. Drainage was again southward through the Mississippi River. The last phase, the Nipigon, began about 9500 BP when the eastern outlets were again opened and Lake Agassiz began its final regression from the area.

Ringrose (1975) suggested that the south pool of Lake Winnipeg drained by 8300 years BP and has subsequently refilled. A date of 1660 ± 60 years (GSC 1977; Lowden and Blake, 1979) was obtained from a sand bar 3.2 km north of Victoria Beach (Twp. 20, Rge. 7E). The position of the sample, from 3 m below the present-day mean lake level, indicates the south pool of Lake Winnipeg is undergoing a southward transgression due to isostatic rebound.

The work of Johnston (1946) remains the most useful for correlating Lake Agassiz strandlines in southeastern Manitoba.

ACKNOWLEDGEMENTS

We would like to thank Ray Blais of the Materials and Research Branch of the Manitoba Department of Highways and Transportation for his cooperation during the backhoe program in the R.M. of Lac du Bonnet; E. Nielsen for critically reading the manuscript; I. du Plessis and R. Wadien for field assistance; M. Carvalho for drafting the maps and figures, M. Giancola, B. Rigby and S. Weselak for typing the manuscript, and Cam Steele for the diagrams illustrating the depositional model of the subaqueous fans.

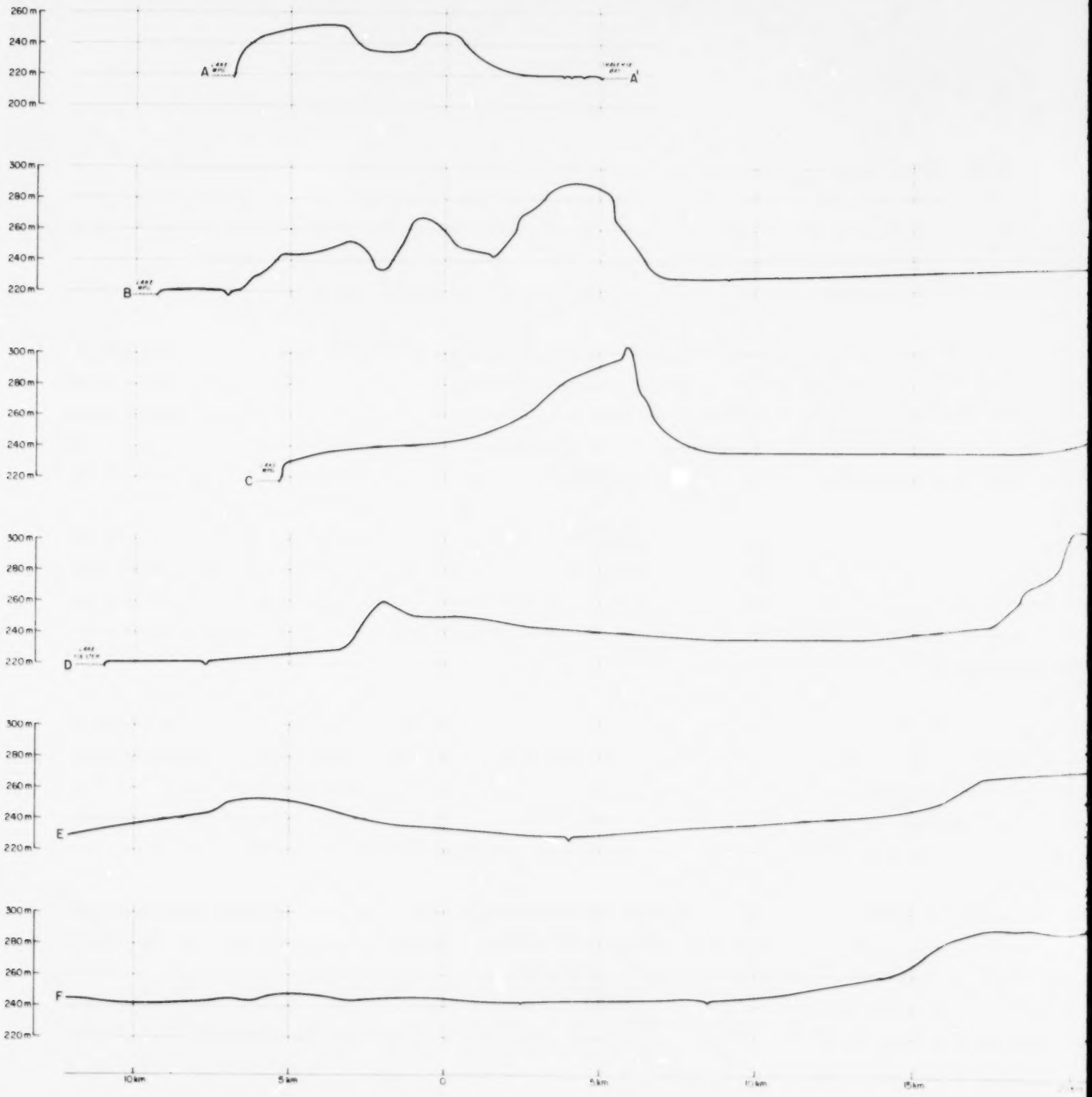
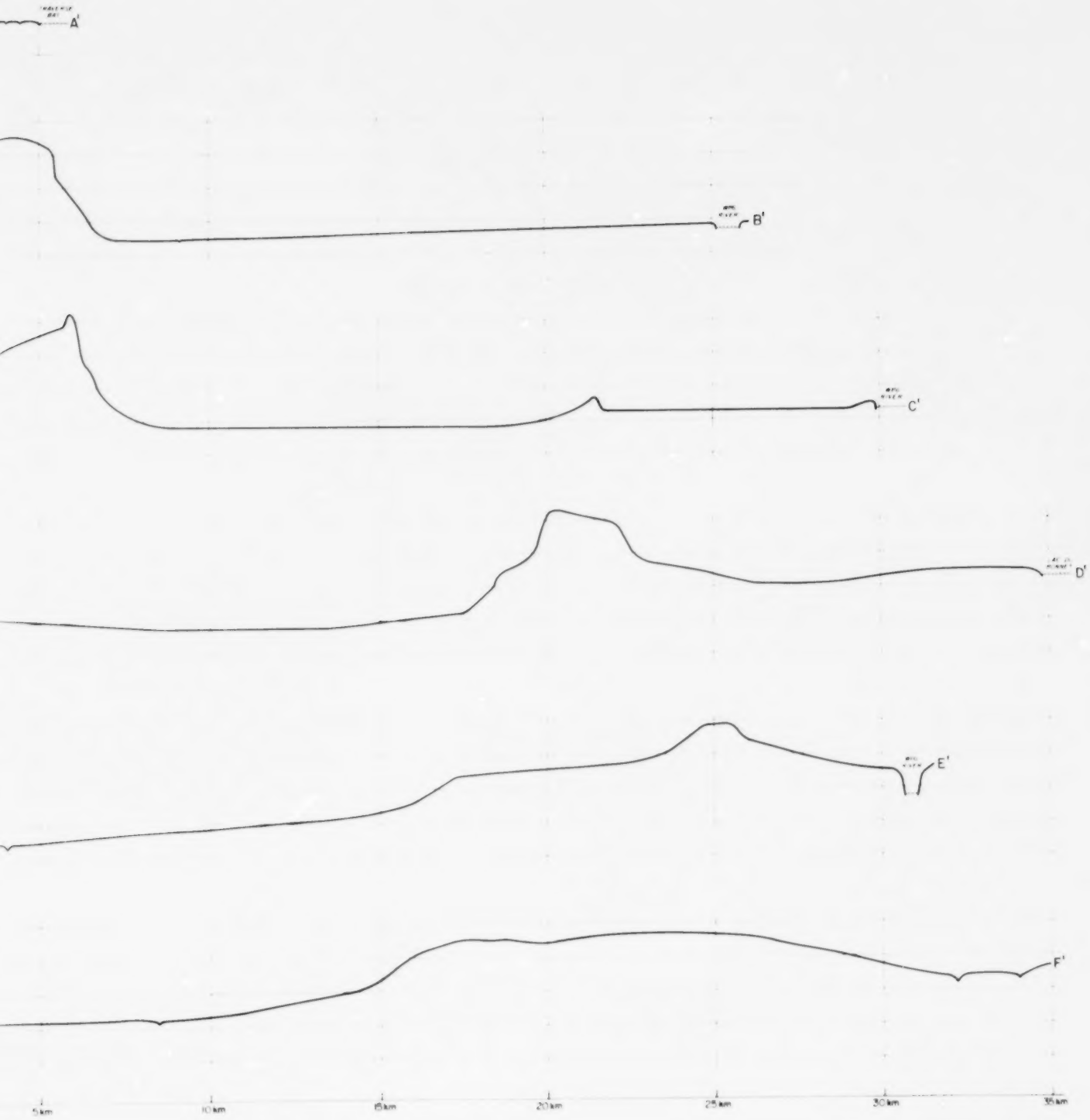


FIGURE 2: Cross-sections showing morphology of Belair and Milner Ridge moraines; cross-section locations shown in Fig. 1.



ection locations shown in Fig. 1.

BEDROCK GEOLOGY

The study area is underlain mainly by granites and gneisses of the Precambrian Shield (Manitoba Mineral Resources Division, 1979). Rocks of the Pine Falls plutonic complex, primarily quartz monzonite, are the major components of the Precambrian bedrock in the area (McRitchie, 1971). The Bird River greenstone belt occurs in the eastern portion of the L.G.D. of Alexander. The greenstone belt consists of "basic volcanics and overlying impure quartzite, arkose, slate and chert" (McRitchie, 1971, p. 10) and has a high resource potential for minerals such as tantalum, lithium, chromium, cesium, rubidium and beryl (Manitoba Mineral Resources Division, 1980; Bannatyne, 1985).

The Ordovician Winnipeg Formation strikes south along the western edge of the area. This 60 m thick formation is subdivided into an upper unit of interbedded shale and sandstone and a basal sandstone unit that is well exposed in quarries on Black Island, north of the area (Baillie, 1952; Watson, 1985). The lower unit is a white, well sorted, medium- to fine-grained sandstone (see Fig. 4) composed of well rounded frosted quartz grains. The sandstone is loosely cemented with kaolin and is easily eroded.

The Winnipeg Formation is overlain by the Ordovician Red River Formation. The lower part of the Red River Formation, the Dog Head Member, is mottled dolomitic limestone which outcrops in the extreme western portion of the study area.

The Manitoba Lowland to the west and northwest of the area is underlain by Paleozoic carbonate bedrock, primarily dolomitic limestone, dolomite and limestone. As much of the L.G.D. of Alexander and the R.M. of Lac du Bonnet were glaciated by ice from the northwest, these lithologies are an important constituent of the tills and gravels in the area.

STRATIGRAPHY OF THE BELAIR AND MILNER RIDGE MORAINES

INTRODUCTION

The Belair and Milner Ridge moraines were deposited on and slightly east of the subcrop belt of the Winnipeg Formation which forms the contact between the Paleozoic carbonate bedrock to the west and crystalline Precambrian rocks to the east (Fig. 1). Consequently, sediment lithology is an important indication of provenance; glacial advances from the east deposited non-calcareous sediments while those from the west deposited calcareous sediments. The Winnipeg Formation is the major source of the sand which is the dominant constituent of the morainal sediments (Nielsen and Matile, 1982).

The stratigraphy of the moraines is shown schematically in Figure 3. The stratigraphy comprises one lower till, a thick sequence of interlobate moraine sediments, and two upper till units. These are overlain by subaqueous fan sediments, a regressive sequence of Lake Agassiz sediments and a thin layer of eolian sand.

Maps AR85-2-1 and 2 (in pocket) show the areal extent of the granular facies of the units described below. Table A-1 (Appendix A) shows the lithology of the 4-16 mm fraction of all the samples. Sample locations are shown on Maps AR85-2-1 and 2.

DESCRIPTION OF UNITS

Lower Till

The lower till was not observed in the present study. McPherson (1970, p. 42) described it as "light olive gray (5Y 6/1) sandy till, containing numerous granitic, volcanic and metasedimentary rock fragments" underlying the Belair and Milner Ridge moraines. Lebedin and Pollock (1978) also observed a sandy till in drill core and correlated it to McPherson's (1970) lower till.

Interlobate moraine sediments

Exposures of the interlobate facies include massive and cross-bedded fine sand, fine Precambrian-rich sandy gravel and rhythmically bedded clayey to sandy silt. The sand facies is the most widespread interlobate sediment. Sand thicknesses of 30 m are common and, north of Stead, thicknesses in excess of 60 m have been found (Teller et al., 1976). The sand is generally white, well to moderately well sorted, and has a mean grain size between 2 and 4 phi (Fig. 4). The sand in places displays ripple-drift crossbedding. Paleocurrent directions centre around 140°.

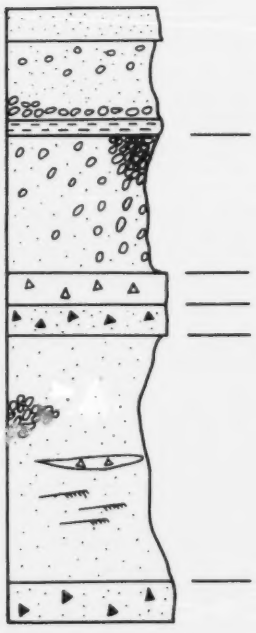


FIGURE 3: Composite stratigraphic section of the Belair and Milner Ridge moraines; modified from Matile and Groom (1983).

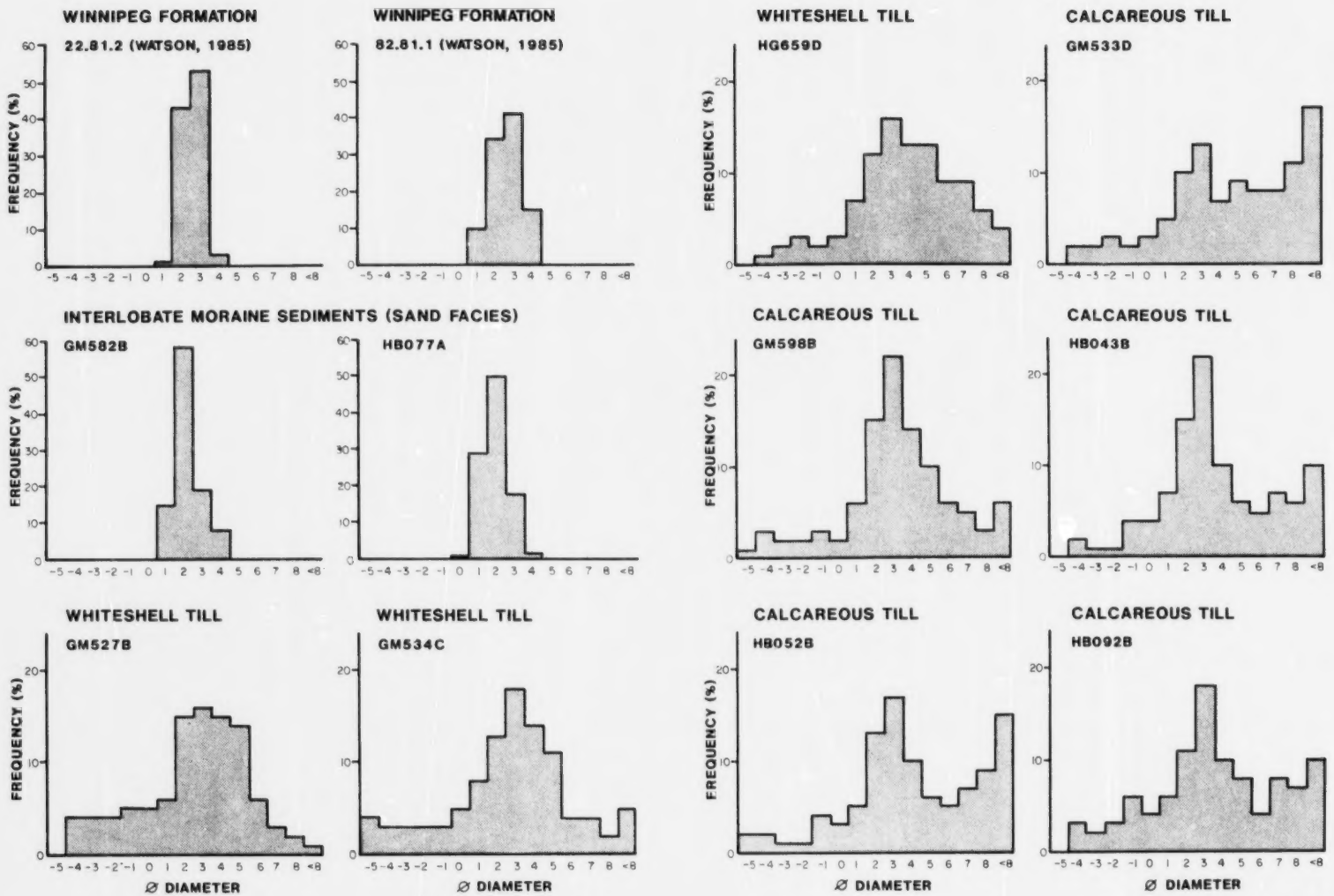


FIGURE 4: Histograms showing the grain size distribution of the Winnipeg Formation sandstone, the sand facies of the interlobate moraine sediments, the Whiteshell till and the calcareous till.

Sand and gravel associated with the interlobate sediment outcrops at two sites (GM527-deposit 3857 and GM528-deposit 3865A). In Figure 5, the lithology of the 4-16 mm fraction of these two samples is compared with that of the other stratigraphic units in the area. Although the lithology of the interlobate facies resembles that of the subaqueous fan sediments (described below) they are differentiated from them by stratigraphic position.

Whiteshell till

A sandy till of northeastern provenance is found within the area of the Belair-Milner Ridge moraines. The till has an average texture of 68% sand, 29% silt and 3% clay (Fig. 4 and 6). The 4-16 mm fraction consists of less than 15% carbonate (Fig. 5). The till is discontinuous and generally less than 2 m thick. It overlies interlobate sediments and is locally overlain by a silty till and subaqueous fan sediments (described below).

The Whiteshell Formation as defined by Teller and Fenton (1980) is a thin discontinuous till with a mean texture of 67.8% sand, 26.6% silt and 5.6% clay that contains less than 20% carbonate clasts in the 4-16 mm fraction. The Whiteshell till was deposited by southwest flowing ice and continued to be deposited in the eastern part of the study area throughout the Late Wisconsinan.

The sandy till is correlated with the upper part of the Whiteshell Formation on the basis of texture, lithology and stratigraphy.

Calcareous till

The uppermost till unit in the Alexander-Lac du Bonnet area is a calcareous till of northwestern provenance. This till is variable in texture (Fig. 6) and pebble lithology. Texture is 46 $\pm$ 16% sand, 37 $\pm$ 11% silt and 17 $\pm$ 8% clay. Pebble composition ranges from 14 to 95% carbonate, with the mode at 65% carbonate clasts (Fig. 5). Within the moraines, the till is discontinuous and generally less than 2 m thick. It overlies interlobate sediments, primarily the sand facies, and, in two places, the Whiteshell till. The lower contact locally shows thrust structures (Fig. 7) or folding of the underlying sand.

The calcareous till exhibits two general trends: 1) an increase in sand in the matrix where the till overlies the interlobate sand facies and, 2) an increase in Precambrian clasts eastward from the Precambrian/Ordovician bedrock contact. These trends are a result of incorporation of the interlobate sand and Precambrian bedrock as the ice sheet advanced southeastward. Incorporation of interlobate sand into the calcareous till is suggested by comparing the texture of the two units; both have strong peaks in the 2-3 phi size range (Fig. 4). The northwestern provenance of the sandy till samples shown in Figure 8 is indicated by pebble lithology and field evidence such as the orientation of z-folds in the underlying sediments (Nielsen and Matile, 1982).

Teller and Fenton (1980) define three calcareous tills of northwestern provenance overlying the Belair and Milner Ridge moraines. All three tills are thin and discontinuous. The lowest unit, the Roseau Formation, was deposited by the main Late Wisconsinan advance of the Red River Lobe out of the Manitoba Lowland. The overlying Whitemouth Lake and Marchand Formations were deposited by minor readvances of the Red River Lobe.

Figure 8 highlights the difficulty of correlating the till samples in this study with the three formations described by Teller and Fenton (1980). Their formations cannot be separated lithologically and the majority of our samples do not fall within the textural limits set for each of their units. Nielsen and Matile (1982) describe three sections (Grand Beach, Hillside Point and Traverse Bay) that expose multiple calcareous till units. However, as Figure 8 illustrates, stratigraphic position cannot be used to determine the formations in each section.

As a result of the problems discussed above, no attempt has been made to "cubbyhole" the individual till samples into the three separate till formations. Instead, the calcareous till unit is simply correlated to the northwest provenance Red River Lobe, representing the variable depositional facies of that ice sheet (see Matile, 1984b).

Subaqueous fan sediments

The subaqueous fan deposits consist of a proximal, inner fan coarse gravel facies grading into a distal, sandy outer fan facies. Ridges of coarse gravel are present in the area of the outer fan (Fig. 9). The subaqueous fan sediments overlie calcareous till and are overlain by Lake Agassiz silt and clay and eolian sand. There is no evidence of glacial overriding.

One hundred and twenty samples were taken from the fan deposits. The Precambrian clast content averages 75% (Fig. 5). Individual clasts are consistently subrounded to well rounded.

The inner fan gravel facies is well exposed in large pits in the Seddons Corner deposit (#3802, Map AR85-2-1) and in the Gull Lake deposit (#4020, Map AR85-2-2).

The Seddons Corner deposit has an inner fan composed of 8 m of predominantly horizontally bedded coarse, clast-supported gravel with crossbedding in the distal portions of the inner fan. The gravel is generally massive but some normal and reverse grading is present (Fig. 10). Individual bed thicknesses average approximately 1 m. Scouring at the base of the inner fan is evident from rip-ups of older sediment in the inner fan gravel. The rip-up clasts commonly appear to be elongated and angular (Fig. 10). This and the presence of graded beds suggest much of the coarse gravel of the inner fan was deposited en masse by sediment gravity flow. A boulder facies is confined to the area north of PTH 44; however, south of PTH 44 clasts larger than 25 cm are rare.

By contrast, the inner fan of the Gull Lake deposit (exposed in the large pit in NW35-16-7E) consists of approximately 15 m of interbedded cobble gravel, pebble gravel and sand (Fig. 11). The material is predominantly crossbedded (Fig. 12); paleoflow is generally southerly but ranges between 130° and 250°. Massive beds of cobbles and boulders are present at the northern (most proximal) end of the pit; boulders are up to 1 m in diameter. Armoured till clasts, scoured from the underlying till are present in the crossbedded gravels at the south end of the pit.

The outer fan facies of all the subaqueous fan deposits is predominantly massive medium to medium-fine sand; in places the sand is crossbedded. Gravel in the outer fan is primarily confined to ridges that radiate southward from the inner fan (Fig. 9). These ridges are up to 4 m high, 30 m wide and range in length from 100 to 1900 m. They are composed of massive, poorly sorted coarse gravel in clast support with minor lenses of crossbedded sand.

The longest ridge in the outer fan of the Seddons Corner deposit was backhoe tested at sixteen sites. Figure 13 shows the maximum grain size along the ridge. At site GM629 (location shown on Fig. 13) the contrasting lithologies of the gravel ridge and the underlying till are evident. The gravel in the ridge contains 74% Precambrian clasts whereas the underlying calcareous till contains only 28% Precambrian clasts.

A depositional model for the subaqueous fans is shown in Figures 14 and 15. The fan deposits were formed by meltwater flowing from the base of the ice into Lake Agassiz, scouring the surface and building the proximal inner and distal outer fan (Fig. 14). The inner fan gravels of the Seddons Corner deposit were emplaced primarily by sediment gravity flow. Fluvial deposition was more prominent at the Gull Lake pit.

The gravel ridges in the outer fan area are believed to have originated as sediment gravity flows as inner fan gravels were carried en masse to the distal portion of the outer fan (Matile, 1984a). Davies and Walker (1974) suggest that the clast support mechanism in coarse grained flows could be a combination of fluid turbulence and the dispersive pressure of clast collisions. This combination of support mechan-

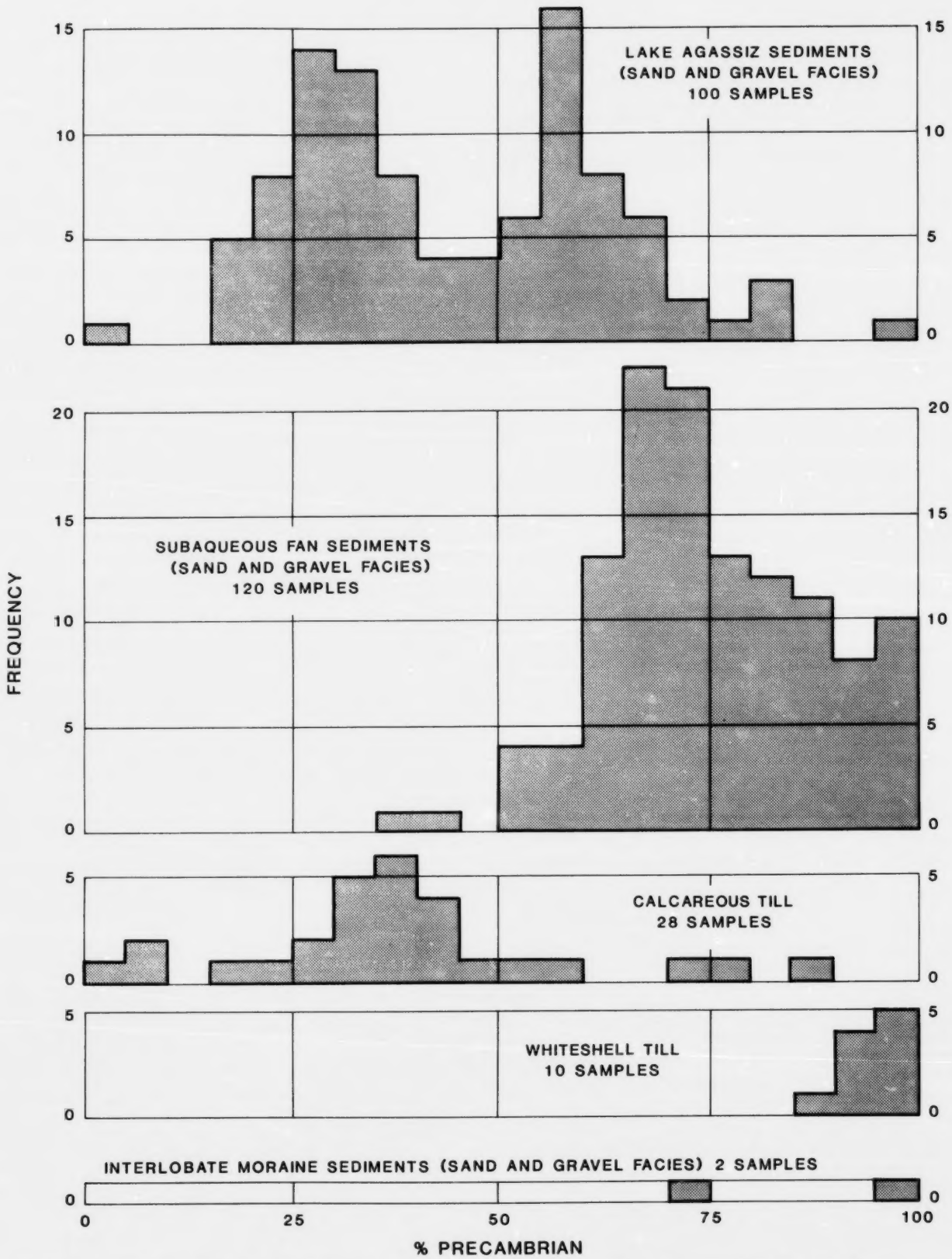


FIGURE 5: Clast lithology of the 4-16 mm size fraction of the stratigraphic units of the Belair and Milner Ridge moraines (oldest unit at bottom).

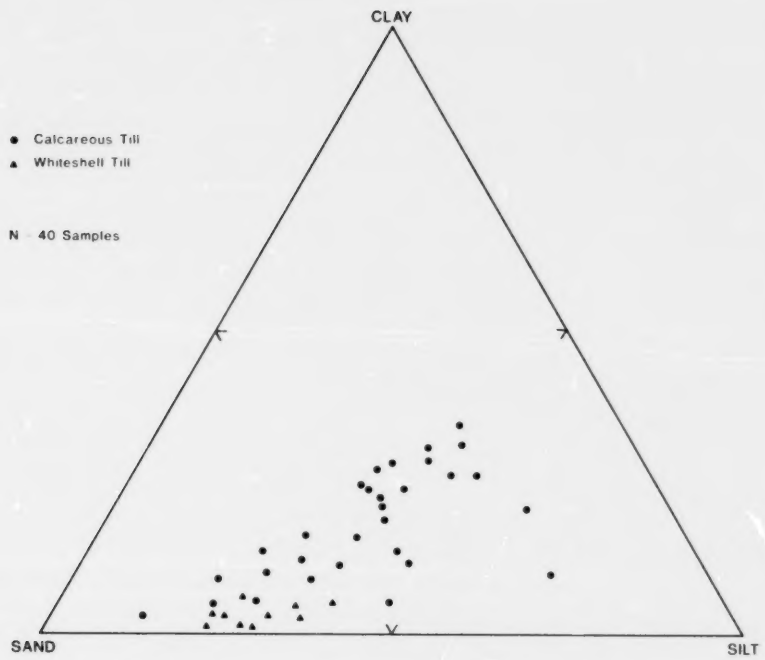


FIGURE 6: Ternary diagram showing matrix texture of the till units.

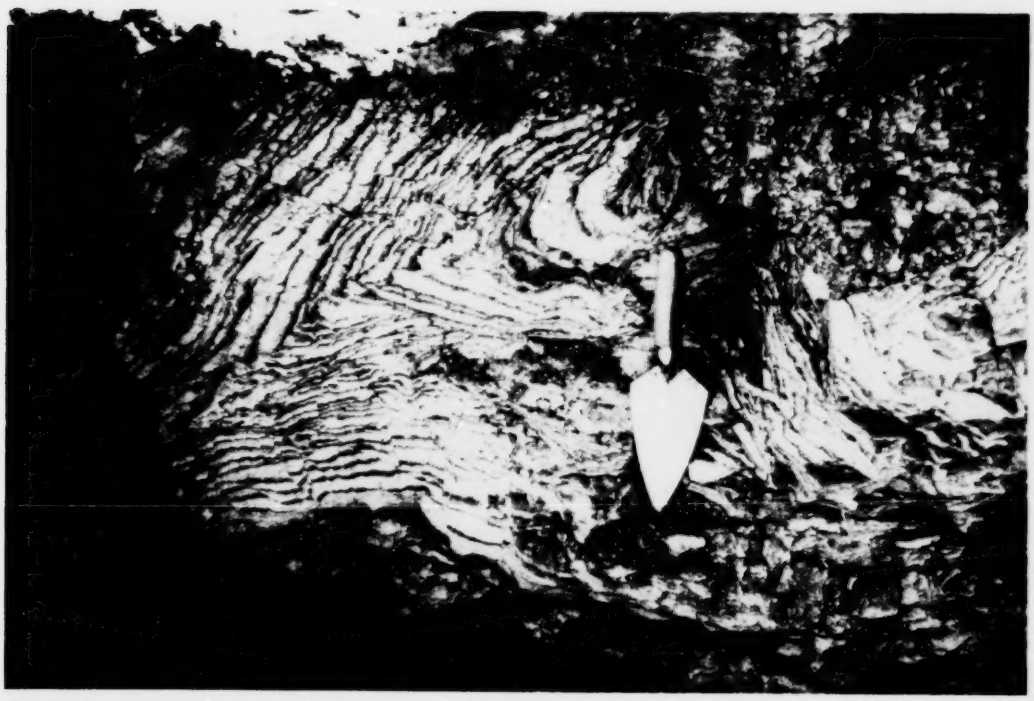


FIGURE 7: Glacial thrusting of calcareous till into underlying rhythmically bedded interlobate sediments (Milner Ridge Pit — NE22-14-10E).

FORMATION	% CARBONATE
MARCHAND FM.	65 ± 15
WHITEMOUTH LAKE FM.	75 ± 13
ROSEAU FM.	70 ± 10

NOTE : ALL NUMBERS ARE % CARBONATE WITHIN TERNARY DIAGRAM

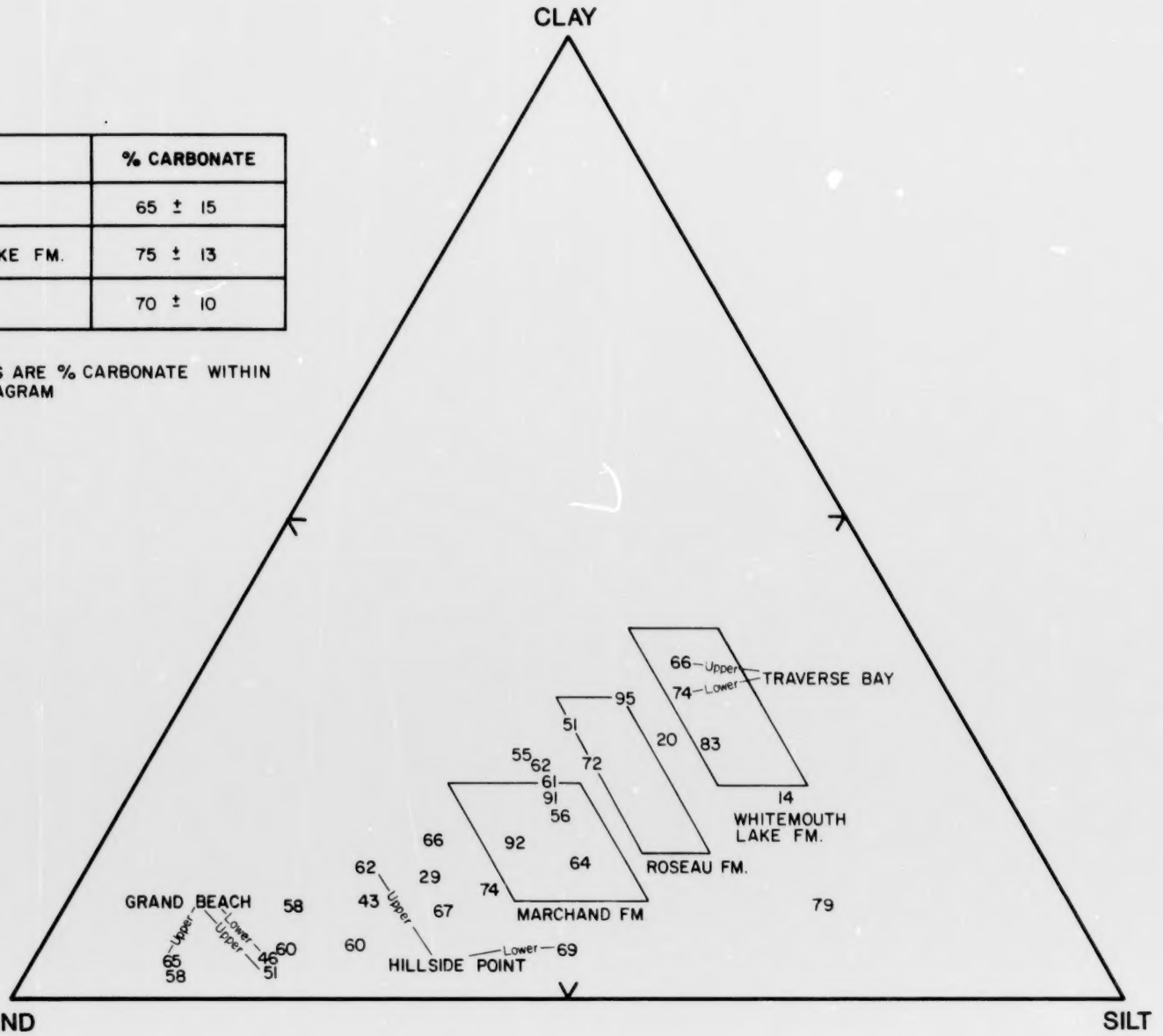


FIGURE 8: Diagram comparing texture and lithology of calcareous till samples from the study area with the three calcareous till formations described by Teller and Fenton (1980).

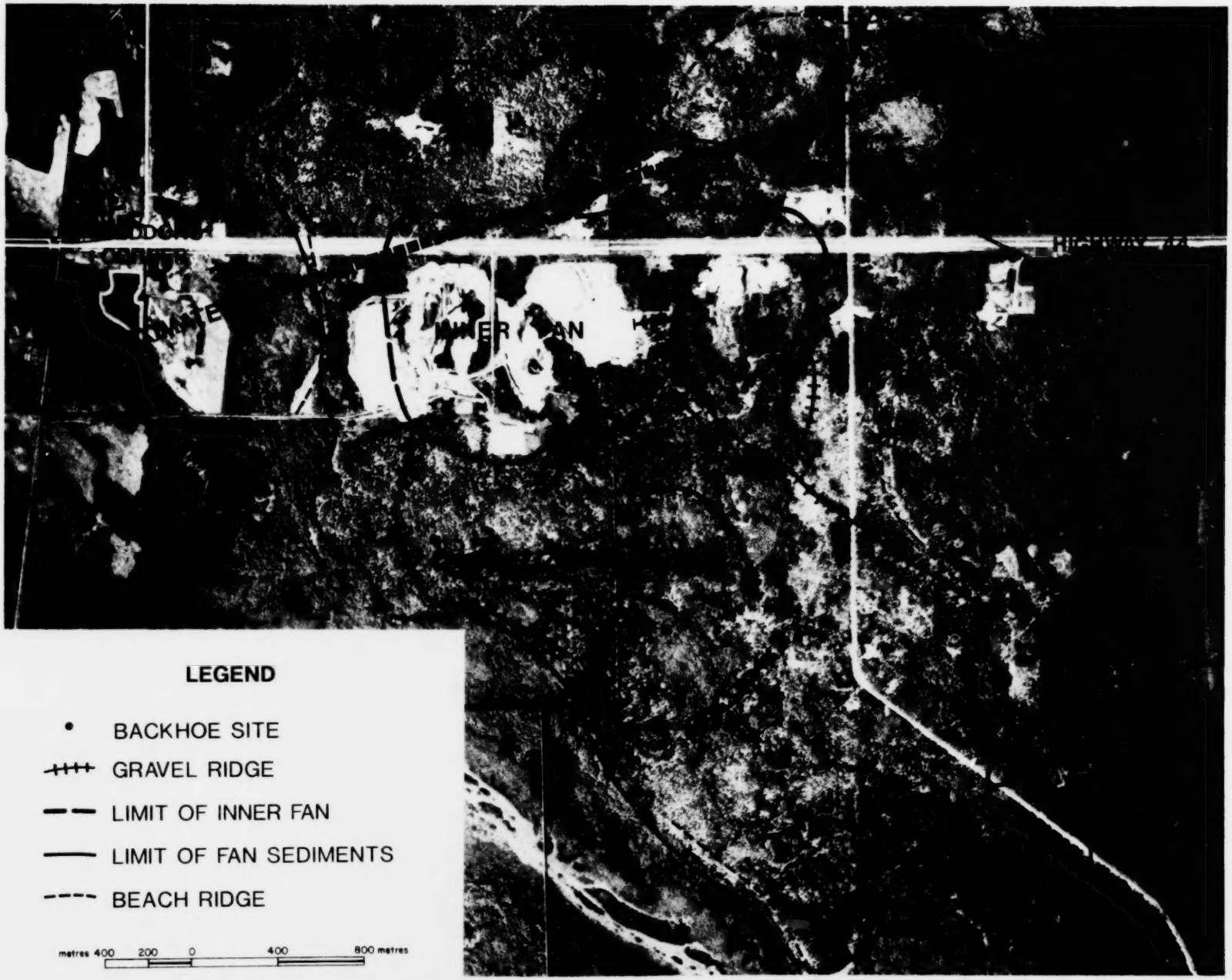


FIGURE 9: Subaqueous fan deposit, showing inner fan and channelized outer fan (Seddons Corner deposit, 3802, extending southward into L.G.D. of Reynolds).

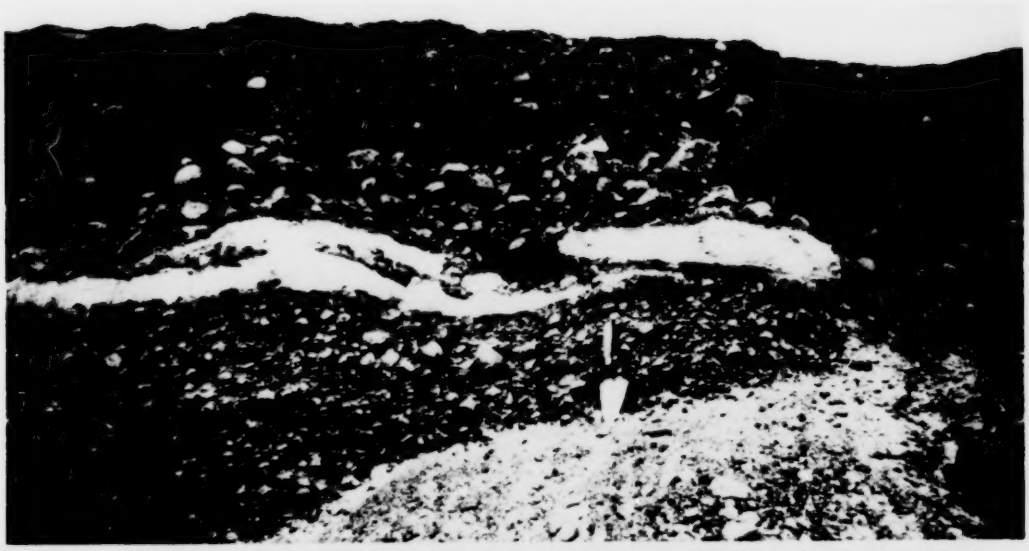


FIGURE 10: Massive gravel of the inner fan facies. Note overlying graded gravel bed and rip-up clast of older sand unit (Seddons Corner deposit in L.G.D. of Reynolds).

FIGURE 11: Gravel of the inner fan facies, Gull Lake pit (NW35-16-7E). Camera lens cap is resting on armoured clast of underlying calcareous till.

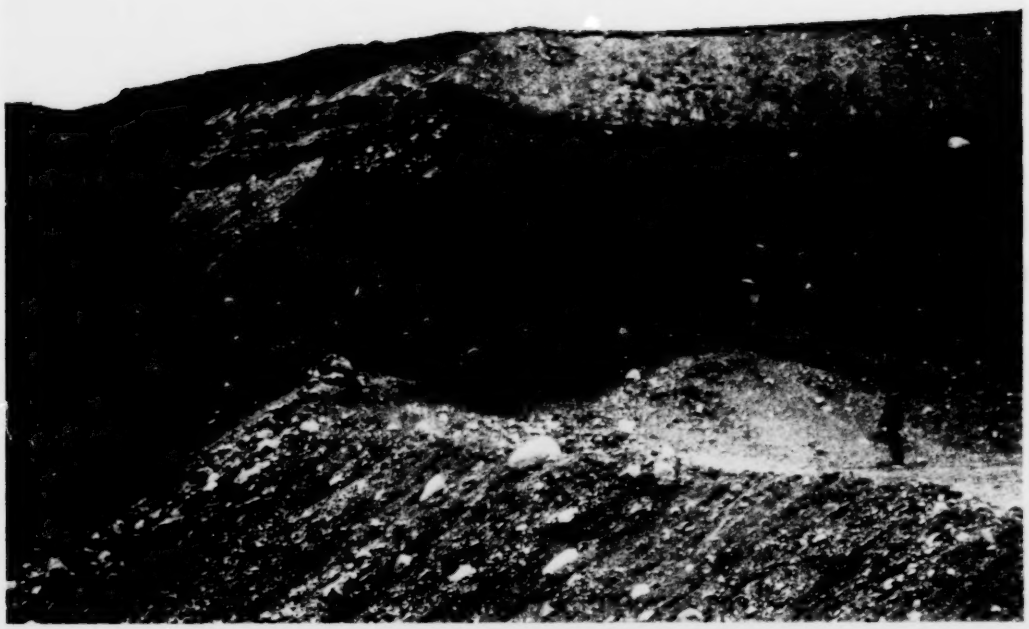


FIGURE 12: Large scale crossbedding in distal portion of inner fan, Gull Lake pit (NW35-16-7E). Paleocurrent direction is southerly.

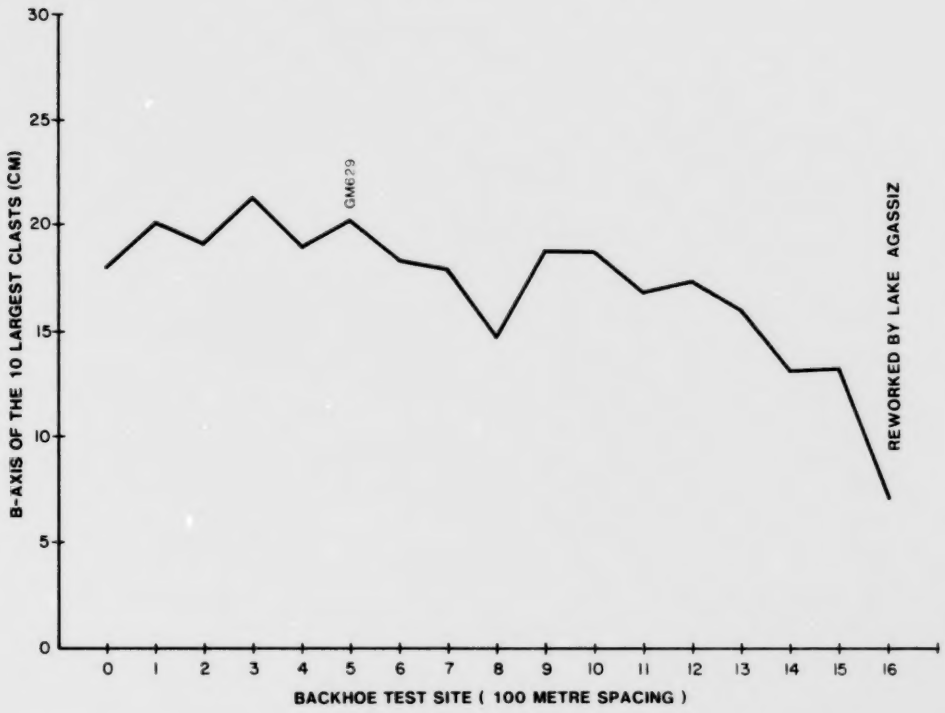


FIGURE 13: Maximum grain size along the length of gravel-filled channel in outer fan.

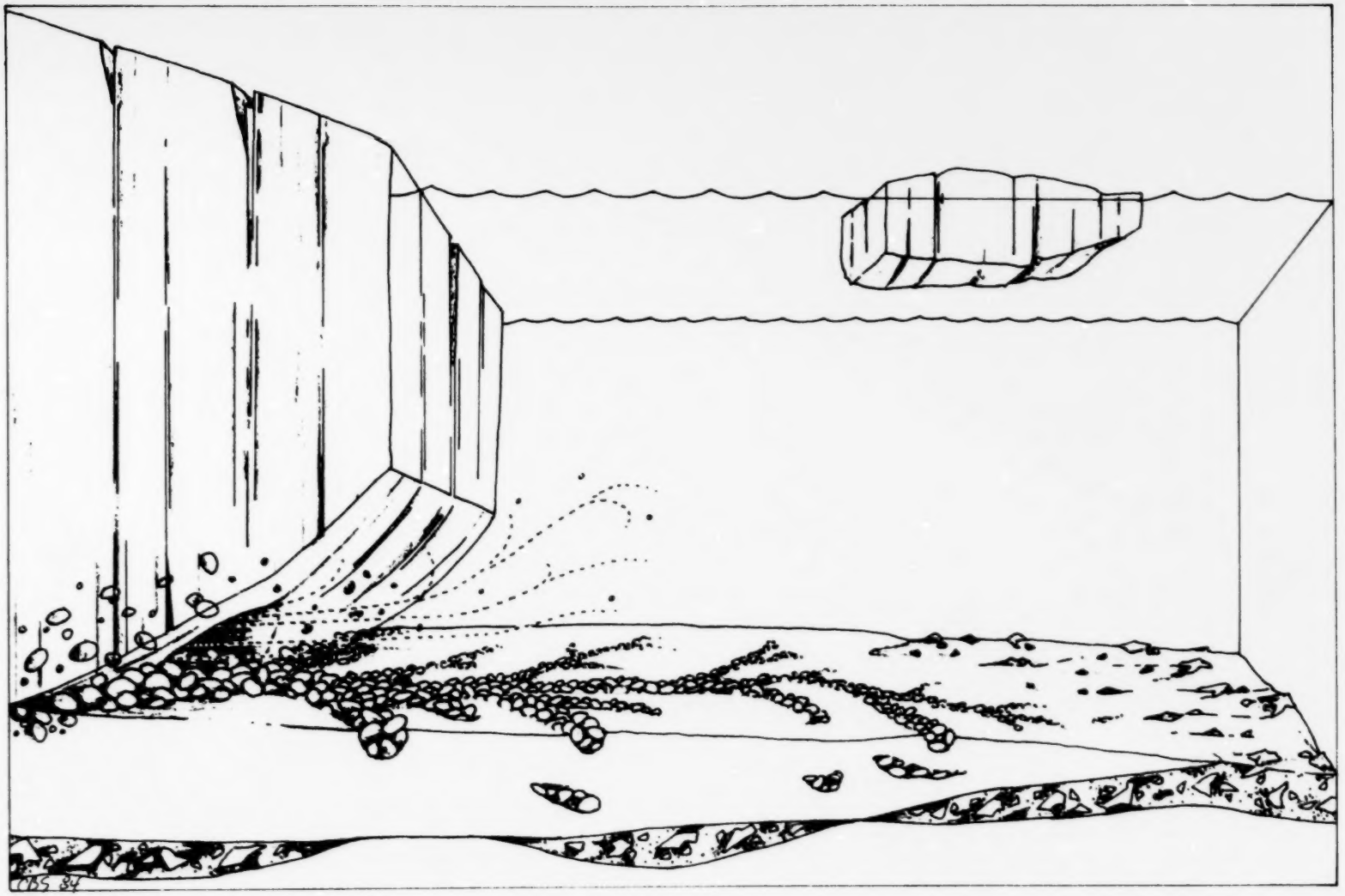


FIGURE 14: Depositional model of subaqueous fan.

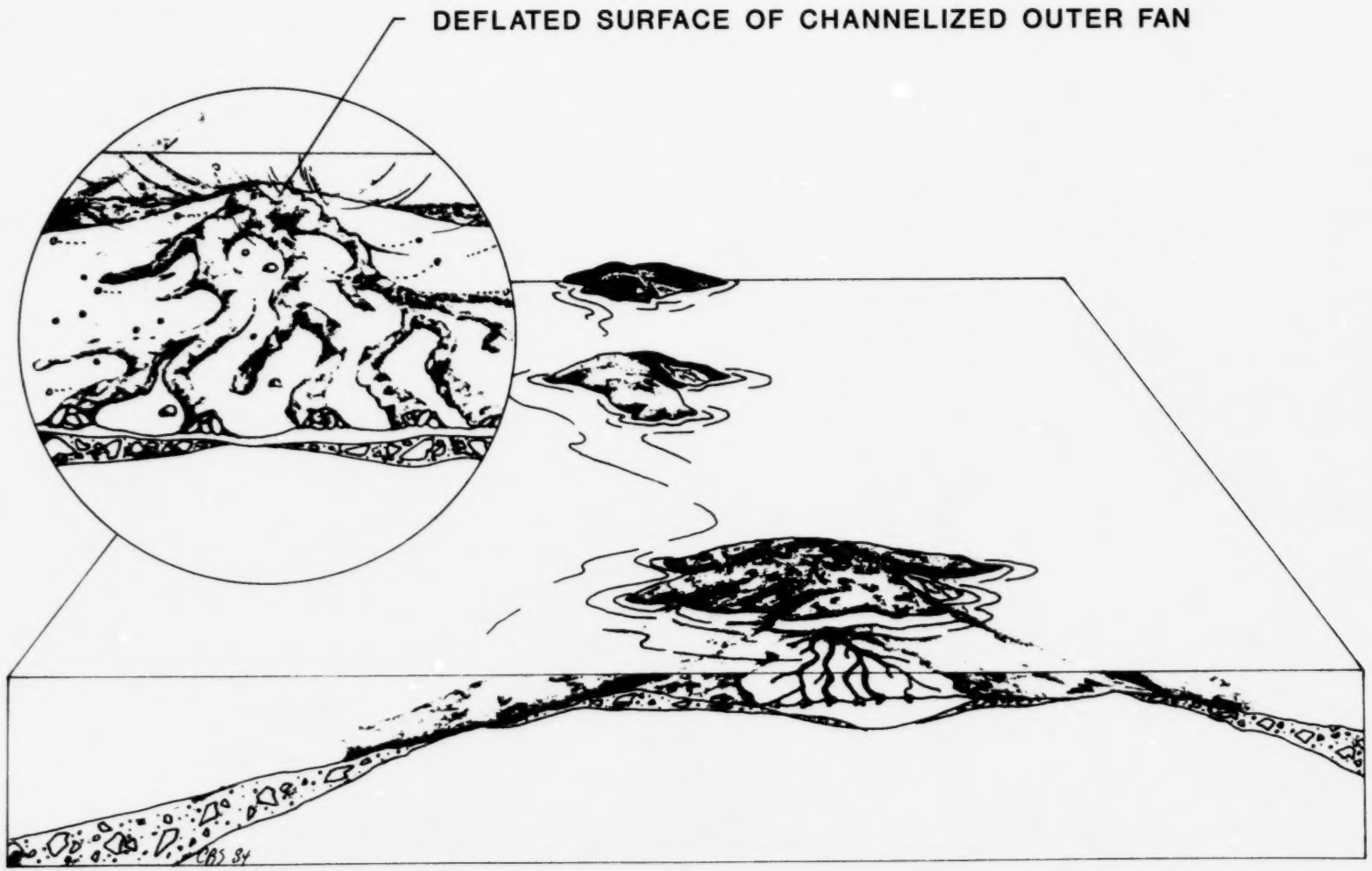


FIGURE 15: Subaqueous fan deposits during the regression of Lake Agassiz. Inset shows ridge morphology after erosion of inter-channel sands.

FIGURE 16: Lake Agassiz beach deposit (A) overlying subaqueous fan gravel (B) in the Gull Lake pit (NW35-16-7E).

isms would result in very rapid flows that once confined to a channel could easily carry coarse gravel to the distal portions of the fan. The non-cohesive nature of the sediment and the distance travelled indicate the flow was confined by a channel. Channel erosion possibly by sediment-laden currents (Cheel and Rust, 1982) and gravel deposition must have been nearly contemporaneous as an open channel would not have been maintained in the saturated sands of the outer fan. During the regression of Lake Agassiz much of the inter-channel sand was eroded, leaving the channel-fill gravels as ridges on the outer fan surface (Fig. 15).

In the depositional model for subaqueous fans presented by Cheel and Rust (1982), soft-sediment deformation structures are common because of rapid deposition. However, Rust (1977) suggests that the general lack of soft-sediment deformation structures in the South Gloucester deposits is a result of a lack of fine sediments. The subaqueous fan sediments in this study also lack the fine sediments and as a result soft-sediment deformation structures were not found.

Numerous boulders, up to 2-3 m in diameter, are present on the fan surface. As boulder-size material is rare in the tills of the area, deflation of the tills by wave erosion cannot account for the large number of boulders. Shilts (1984) suggests that an englacial tunnel (the source of the subaqueous fan sediments) draws glacial ice laterally into the tunnel, constantly melting the ice walls and therefore concentrating a disproportionate amount of coarse debris. This coarse material is then deposited near the mouth of the conduit or melted out of the ice as the ice front retreats. In a subaqueous environment, this model accounts for the concentration of coarse material found in the inner fan. The boulders on the fan surface were deposited as dropstones derived from glacier ice floating over the active fan (Cheel and Rust, 1982, p. 282).

Postglacial sediments

Postglacial sediments include glaciolacustrine deposits, eolian sand, extensive peat deposits and minor alluvium.

Glaciolacustrine sediments are widespread throughout the area. Clay is found in isolated pockets in the high areas and as a blanket in the low areas surrounding the moraines. Granular glaciolacustrine deposits, including beach ridges, sand spits and ice-push ridges, overlie till or subaqueous fan deposits (Fig. 16).

Beach ridges, 2 to 3 m high, are composed of horizontally bedded sandy pebble gravel. Analysis of 100 beach ridge samples shows they have a smaller maximum grain size and a higher carbonate content than the glaciofluvial gravels. Lithologically, the beach deposits fall into two groups (Fig. 5). The material in deposits high in carbonate clasts was eroded primarily from the underlying calcareous till whereas deposits high in Precambrian clasts were derived from the subaqueous fans.

The ice-push ridge, map unit 2d (Map AR85-2-1), consists of a bouldery core blanketed by horizontally bedded beach gravel. Figure 17 shows the ridge morphology and Figure 18 is an isopach map of the deposit; the thickest area comprises the boulder core. The ice-push ridge was formed when Lake Agassiz was at the Ossawa level. It is situated on a gentle till-covered slope that was the source of the material making up the boulder core. Enough emergent land existed at the Ossawa level to maintain the build-up of shore ice between islands during the winter. This confined ice mass provided the onshore thrust necessary to pluck boulders and other surficial debris from their shallow nearshore environment and drive them onshore. This mechanism of onshore ice thrusting resulting from a repeated cycle of thermal expansion and contraction of lake ice is present today in the nearby south pool of Lake Winnipeg (Manitoba Water Resources Division, 1977). Modern day equivalents of similar size and composition are well documented in the literature (see Dionne, 1979 and McPherson, 1970).

The youngest sedimentary unit is eolian sand, including scattered sand dunes, and is found throughout the morainal areas. The dunes, up to 3 m high, are composed of fine grained (median = 2 phi), moderately well sorted sand (20 samples analyzed). The dunes are stabilized by vegetation and in places support stands of pine trees. There is also a thin discontinuous eolian sand layer blanketing much of the morainal area. The sand is massive, stone-free and generally less than 0.5 m thick. Based on a limited number of samples(9) this layer tends to be slightly coarser (median = 1 phi), and less well-sorted than the dune sand.

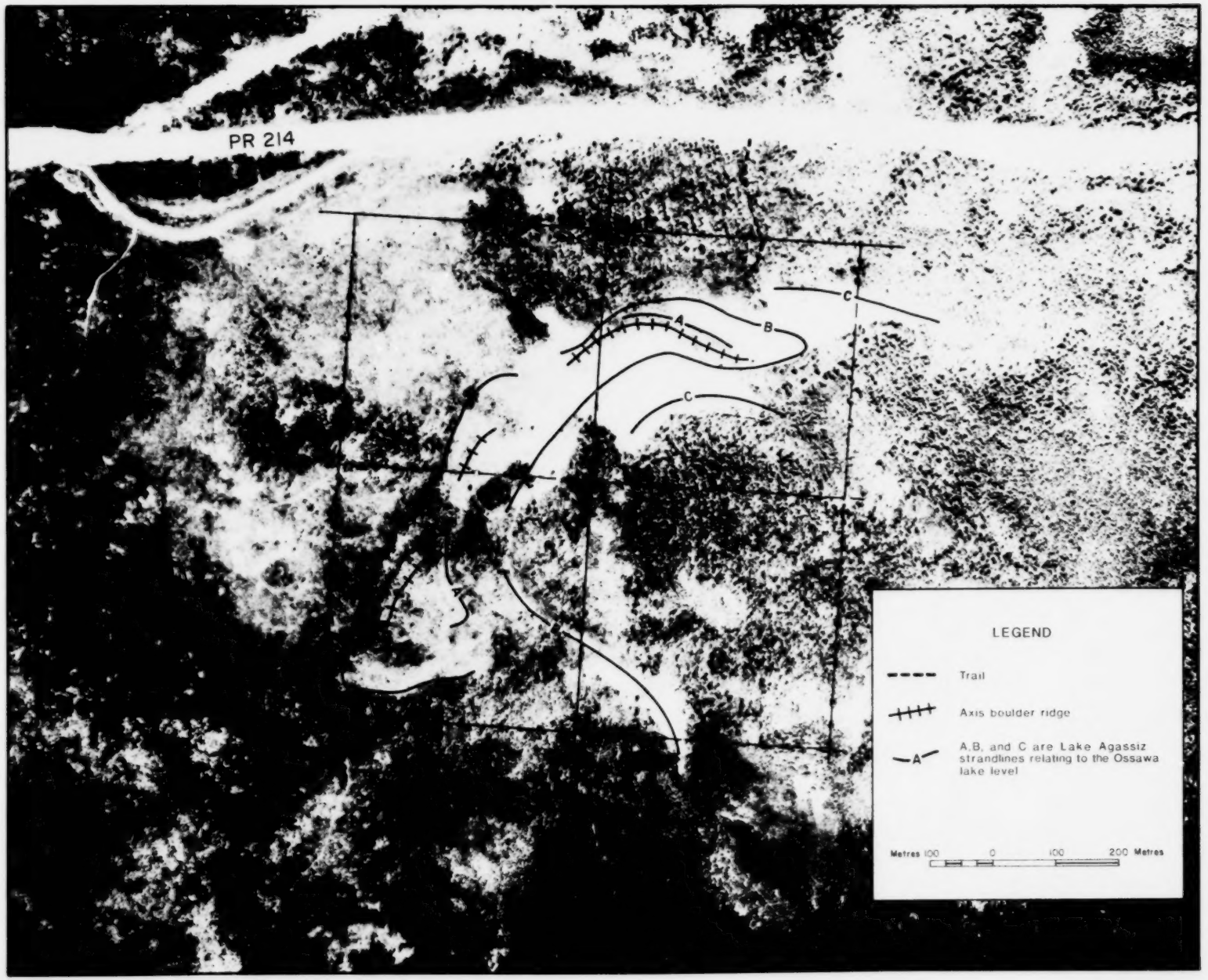


FIGURE 17: Morphology of ice-push ridge (Deposit 3848).

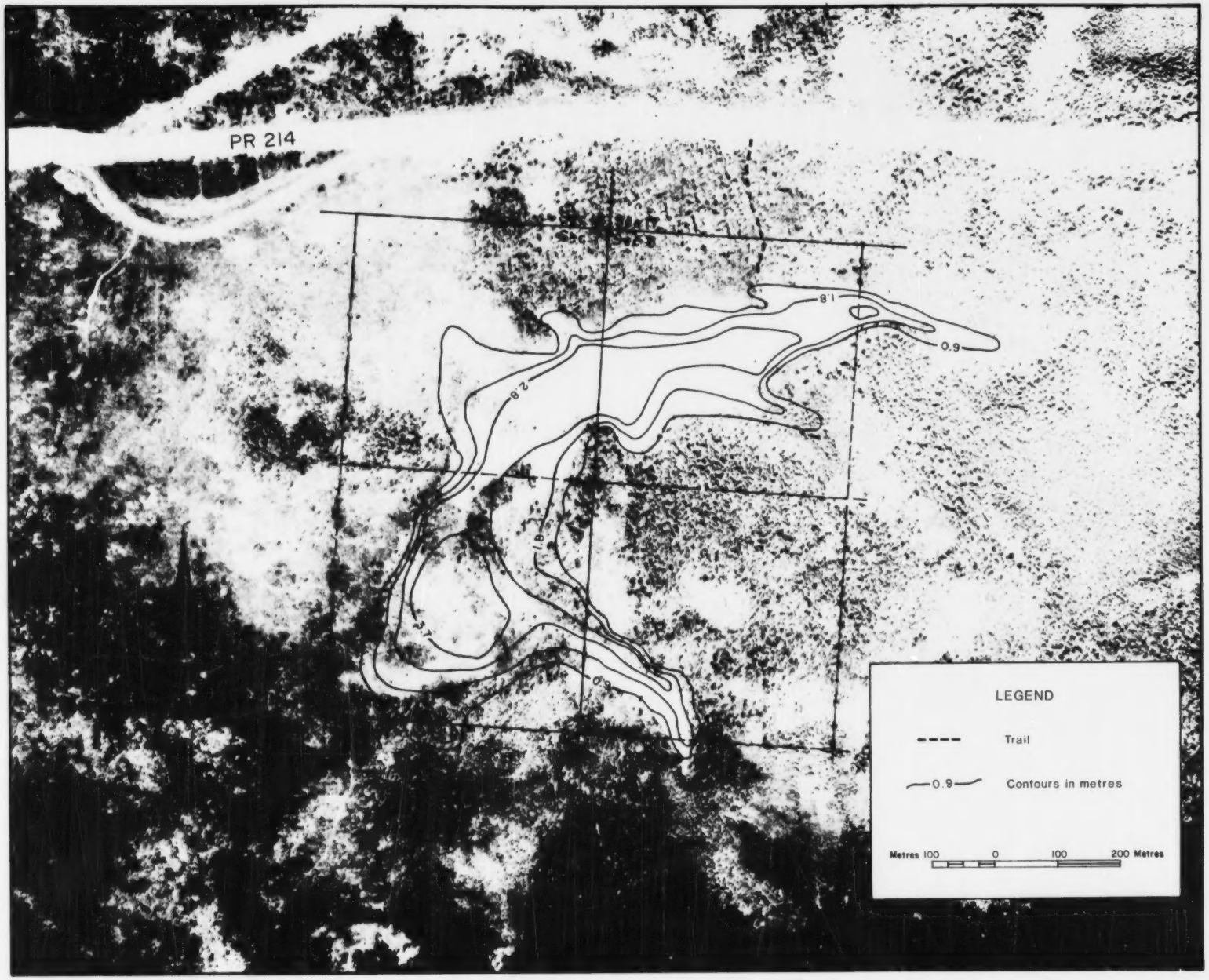


FIGURE 18: Isopach diagram of ice-push ridge delineating aggregate thickness.

LATE WISCONSINAN HISTORY

Two major ice lobes affected the R.M. of Lac du Bonnet and the L.G.D. of Alexander during the Late Wisconsinan. The first advanced from the northeast to an unknown point in southern Manitoba and deposited the Precambrian-rich Senkiw till and its eastern lateral equivalent, the Whiteshell till.

During its retreat the northeast ice stabilized first in the vicinity of the Belair moraine and then at Milner Ridge moraine. At both these locations it was met by the advancing Red River Lobe, which flowed toward the southeast and deposited the calcareous till.

At the confluence of these two ice sheets, prior to 14 000 years BP, white sand and associated morainal sediments were deposited by meltwater that flowed southward between the two lobes into a predecessor of Lake Agassiz (Teller and Fenton, 1980). This was the major building event of the Belair and Milner Ridge interlobate moraines (Fig. 19).

A minor fluctuation of the northeastern ice deposited the Whiteshell till over parts of the moraines before the Red River Lobe expanded and overrode the two moraines. The interlobate position between the two ice lobes shifted to the east as the Red River Lobe flowed southward (Fig. 20a, ice margins A to C), and reached its maximum in Des Moines, Iowa around 14 000 years BP (Teller and Fenton, 1980).

During deglaciation, the suture between the Red River lobe and the northeastern ice migrated westward (Fig. 20b, ice margins D to G). This westward migration is indicated by the fact that the uppermost glacial units (the subaqueous fan deposits) are of northeastern provenance. This is supported by the deposition of the Mantagao Ridge interlobate moraine in the Fisher Branch area to the north (Groom, 1985).

With the final retreat of glacial ice, the area was inundated by Lake Agassiz. Figure 21 depicts the shoreline features and four prominent lake levels attributed to the Nipigon Phase of Lake Agassiz. The first emergent land occurred at the time of the Ojata level; by the Gimli level all but the low plain areas were dry land. Lake terraces, beach ridges and spits were formed during this period.

Eolian activity following the draining of Lake Agassiz deposited isolated pockets of sand dunes and a thin discontinuous blanket of sand throughout the area.

FIGURE 19: Depositional model of interlobate moraine.

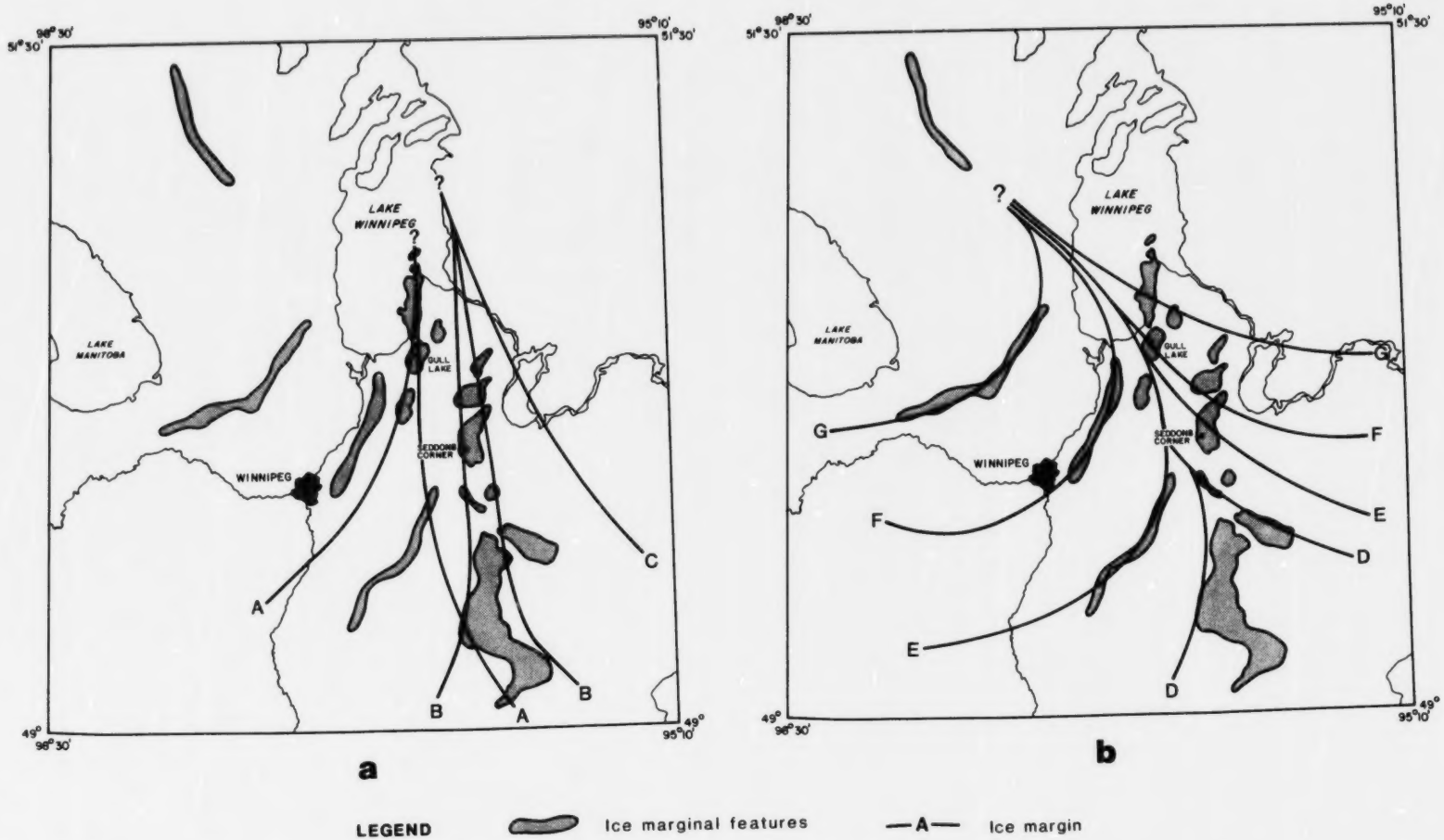


FIGURE 20: Ice marginal positions during the Late Wisconsinan glaciation (a) and deglaciation (b) of southeastern Manitoba.

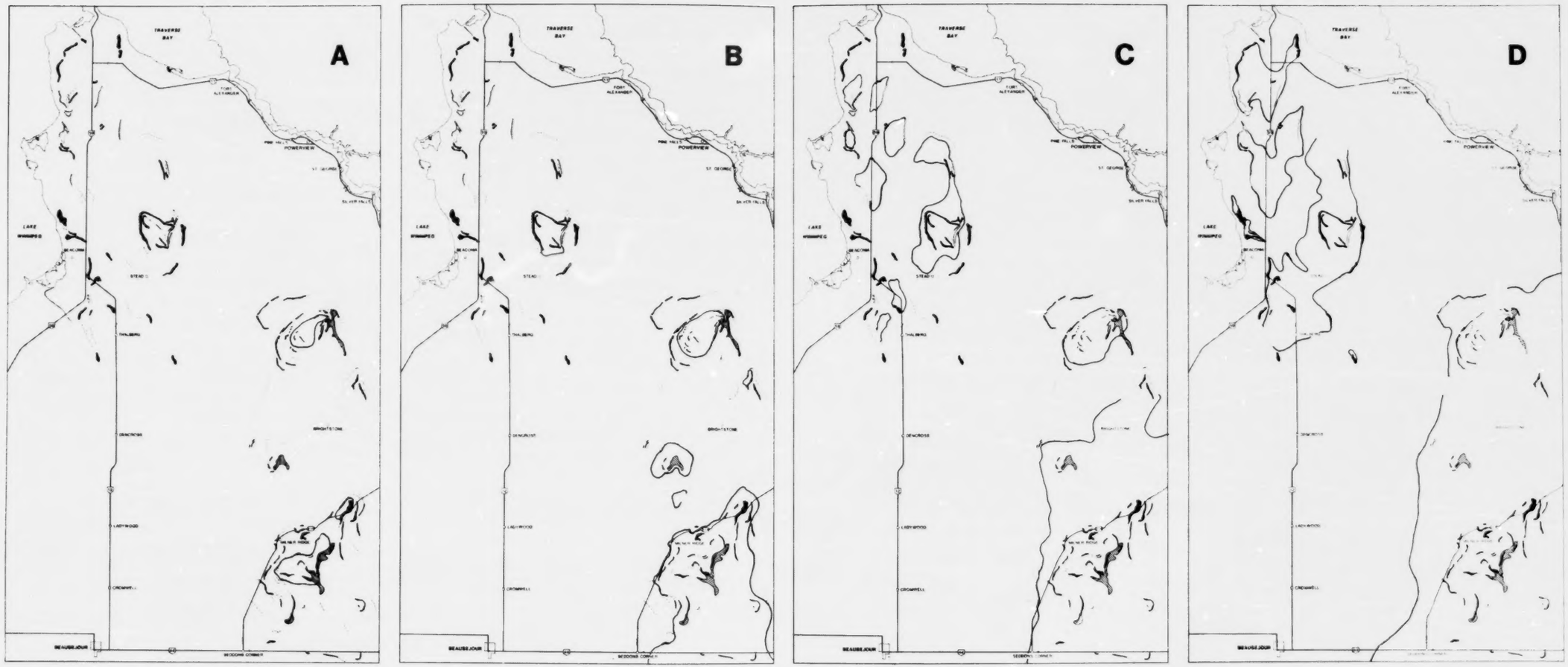


FIGURE 21: Reconstruction of four major levels of Lake Agassiz:
(A) Burnside
(B) Stonewall
(C) The Pas
(D) Gimli

SAND AND GRAVEL RESOURCES

The sand and gravel resources of the R.M. of Lac du Bonnet and the L.G.D. of Alexander are found in glaciofluvial and glaciolacustrine deposits scattered throughout the area. The tables in Appendix B summarize relevant information for each of the deposits. Deposit numbers referred to in tables are found on Map AR85-2-1 to 4 (in pocket). Maps AR85-2-1 and AR85-2-2 classify the deposits by origin whereas maps AR85-2-3 and AR85-2-4 describe deposit quality. The northeastern portion of the R.M. of St. Clements has been included on the L.G.D. of Alexander maps (maps AR85-2-2 and AR85-2-4). Grain size data are given in Appendix C. Figure C-1 shows the limits of granular descriptive terms (e.g. sandy fine pebble gravel) used throughout the text.

The glaciofluvial deposits contain over half the estimated aggregate reserves in the area (Table 1). The deposits are located primarily in the L.G.D. of Alexander and the R.M. of St. Clements. Deposit 3802, in the R.M. of Lac du Bonnet, is part of a large glaciofluvial deposit similar to those in the north. However, the larger part of the reserves in that deposit lie south of the area in the L.G.D. of Reynolds and have not been included in Table 1.

Most of the glaciofluvial deposits have been mined, some extensively. Pit depths range from 2 to 20 m. Most of the pits are used on an intermittent basis but there is a large-scale, permanent gravel operation in NW35-16-7E (deposit 4020). Deposits 3802, 4020, 4026, 4410 and 4413 are the most active deposits. Much of the aggregate used by the L.G.D. of Alexander comes from Deposit 4413.

Beach ridges are the most important source of sand and gravel in the R.M. of Lac du Bonnet due to the lack of large glaciofluvial deposits in the municipality. Most of the deposits have small pits used on an intermittent basis and there are several that have been extensively mined. The Milner Ridge pit, NW23-14-10E, is up to 5 m deep and is one of the major suppliers of aggregate for the area. Most of the gravel used by the R.M. of Whitemouth is taken from the pit in deposit 3808B. The glaciolacustrine ridges in the L.G.D. of Alexander are of minor economic importance although deposits 4408 and 4409 have been extensively mined and are near depletion.

There is an estimated 24.5 million m^3 of aggregate reserves in the R.M. of Lac du Bonnet and the L.G.D. of Alexander and an additional 10.5 million m^3 in the mapped portion of the R.M. of St. Clements. Forecasted demand in the Lac du Bonnet-Alexander area over the next 25 years is 9 million m^3. Although these figures show an abundance of gravel is present to meet the needs of the area, the deposits are not equally distributed throughout the region. A scarcity of gravel east of the Winnipeg River (Nielsen, 1986) has resulted in several bedrock quarries having been opened to provide aggregate for road construction. Bedrock quarry locations are shown on Manitoba Mines Branch Map 80-1.

TABLE 1
ESTIMATED RESERVES AND DEMAND FOR SAND AND GRAVEL

Location	Deposit Type		Total Reserves ('000 m^3)	Demand[1] Forecast-25 yrs. ('000 m^3)
	Glaciofluvial ('000 m^3)	Glaciolacustrine ('000 m^3)		
R.M. of Lac du Bonnet	3 680	10 994	14 674	4 641
L.G.D. of Alexander	6 253	3 575	9 828	4 425
R.M. of St. Clements (eastern portion)	8 796	2 685	10 481	—
TOTALS:	18 729	16 254	34 983	9 066

[1] Demand data from C. Jones (1984a, 1984b).

REFERENCES

Baillie, A.D.
1952: Ordovician geology of Lake Winnipeg and adjacent areas, Manitoba; Manitoba Mines Branch, Publication 5-16, 64 p.

Bannatyne, B.B.
1985: Industrial minerals in rare-element pegmatites of Manitoba; Manitoba Energy and Mines, Economic Geology Report ER84-1, 96 p.

Bird, J.B.
1972: The natural landscapes of Canada; Wiley Publishers of Canada Limited, p. 117-120.

Cheel, R. J. and Rust B. R.
1982: Coarse grained facies of glacio-marine deposits near Ottawa, Canada; **in** Research in glacial, glacio-fluvial, and glacio-lacustrine systems, R. Davidson-Arnott, W. Nickling and B.D. Fahey, (ed.); Department of Geography, University of Guelph, Geographic Publication No. 6, p. 279-295.

Davies, I.C. and Walker, R.G.
1974: Transport and deposition of resedimented conglomerates: The Cape Enrage Formation, Cambro-Ordovician, Gaspe, Quebec; Journal of Sedimentary Petrology, v. 44, p. 1200-1216.

Dionne, J.C.
1979: Ice action in the lacustrine environment. A review with particular reference to subartic Quebec, Canada; Earth-Science Reviews, v. 15, p. 185-212.

Elson, J.A.
1983: Glacial Lake Agassiz — discovery and a century of research; **in** Glacial Lake Agassiz, J.T. Teller and L. Clayton (ed); Geological Association of Canada, Special Paper 26, p. 21-41.

Fenton, M.M.
1974: The Quaternary stratigraphy of a portion of southeastern Manitoba, Canada; unpublished Ph.D thesis, University of Western Ontario, 286 p.

Fenton, M.M., Moran, S.R., Teller, J.T. and Clayton, L.
1983: Quaternary stratigraphy and history in the southern part of the Lake Agassiz basin; **in** Glacial Lake Agassiz, J.T. Teller and L. Clayton (ed.); Geological Association of Canada, Special Paper 26, p. 49-74.

Folk, R.L.
1974: Petrology of sedimentary rocks; Hemphill Publishing Co., 184 p.

Groom, H.D.
1985: Surficial geology and aggregate resources of the Fisher Branch area: Local Government District of Fisher and Rural Municipality of Bifrost; Manitoba Energy and Mines, Aggregate Report AR84-2, 33 p.

Johnston, W.A.
1923: Surface deposits and ground-water supply of the Winnipeg map area, Manitoba; Geological Survey of Canada, Memoir 174, 110 p., Map 254A.

1946: Glacial Lake Agassiz, with special reference to the mode of deformation of the beaches; Geological Survey of Canada, Bulletin No. 7, 20 p.

Jones, C.W.
1984a: Aggregate resources in the R.M. of Lac du Bonnet; Manitoba Mines Branch, 63 p.

1984b: Aggregate resources in the Winnipeg River planning district; Manitoba Mines Branch, 47 p.

Lebedin, J. and Pollock, D.H.
1978: Groundwater resources of the Beausejour area, Manitoba; Canada Department of Regional Expansion, Prairie Farm Rehabilitation Administration, Engineering Service, Regina (unpublished).

Lowden, J.A. and Blake, W. Jr.
1979: Geological Survey of Canada radiocarbon dates XIX; Geological Survey of Canada, Paper 79-7, 58 p.

Manitoba Mineral Resources Division
1979: Geological Map of Manitoba; Manitoba Mineral Resources Division, Map No. 79-2.

1980: Mineral Map of Manitoba; Manitoba Mineral Resources Division, Map No. 80-1.

1981: Surficial Geological Map of Manitoba; Manitoba Mineral Resources Division, Map No. 81-1.

Manitoba Water Resources Division
1977: The Lake Winnipeg shoreline handbook; Department of Mines, Resources and Environmental Management, 46 p.

Matile, G.
1984a: Aggregate resources in the L.G.D. of Reynolds; Manitoba Mineral Resources Division, Report of Field Activities, 1984 p. 176-178.

Matile, G.
1984b: Quaternary geology map of the Birds Hill area; Manitoba Energy and Mines, Map AR84-5.

Matile, G. and Groom, H.
1983: Aggregate resources in the L.G.D. of Alexander and the R.M. of Lac du Bonnet; in Manitoba Mineral Resources Division, Report of Field Activities, 1983, p. 155-158.

McPherson, R.A.
1970: Pleistocene geology of the Beausejour area; Unpublished Ph.D. thesis, University of Manitoba, 153 p.

McRitchie, W.D.
1971: The petrology and environment of the acidic plutonic rocks of the Wanipigow-Winnipeg Rivers region, southeastern Manitoba; in Geology and geophysics of the Rice Lake region, southeastern Manitoba (Project Pioneer), W.D. McRitchie and W. Weber (ed.); Manitoba Mines Branch, Publication 71-1, p. 7-61.

Nielsen, E.
1986: Quaternary geology of a part of southeastern Manitoba, 1:100 000; Manitoba Mineral Resources Division (to accompany Geological Report GR80-6, in prep.).

Nielsen, E. and Matile, G.
1982: Till stratigraphy and proglacial lacustrine deposits in the Winnipeg area. Field trip guidebook, Trip 1; Geological Association of Canada-Mineralogical Association of Canada, 22 p.

Ringrose, S.
1975: A re-evaluation of late Lake Agassiz shoreline data from north central Manitoba; The Albertan Geographer, v. 11, p. 33-41.

Rust, B.R.
1977: Mass flow deposits in a Quaternary succession near Ottawa, Canada: diagnostic criteria for subaqueous outwash; Canadian Journal of Earth Sciences, v. 14, p. 175-184.

Shilts, W.W.
1984: Esker sedimentation models, Deep Rose Lake map area, District of Keewatin; in Current Research, Part B, Geological Survey of Canada, Paper 84-1B, p. 217-222.

Smith, R.E. and Ehrlich, W.A.
1967: Soils of the Lac du Bonnet area; Manitoba Soil Survey, Report No. 15, 118p.

Teller, J. T., Bannatyne, B.B., Large, P. and Ringrose, S.
1976: Total thickness of clay, silt, sand, gravel and till in southern Manitoba; Manitoba Mineral Resources Division, Surficial Map 76-1.

Teller, J.T. and Fenton, M.M.
1980: Late Wisconsinan glacial stratigraphy and history of southeastern Manitoba; Canadian Journal of Earth Sciences, v. 17, p. 19-35.

Upham, W.
1890: Report on exploration of the glacial Lake Agassiz in Manitoba; Geological Survey of Canada Annual Report for 1888-1889, v.4, section E, 156 p.

Watson, D.M.
1985: Silica in Manitoba; Manitoba Energy and Mines, Economic Geology Report ER84-2, 35 p.

APPENDIX A: SAMPLE LITHOLOGY DATA

TABLE A-1
LITHOLOGY OF THE 4-16 MM PEBBLE FRACTION OF ALL SAMPLES

Sample #	Precambrian %	Carbonate %	Sample #	Precambrian %	Carbonate %
GM507	98	2	GM549	22	78
GM508A	100	-	GM550	17	83
GM508B	86	14	GM551A	31	69
GM509	85	15	GM551B	72	28
GM510	76	24	GM551C	21	79
GM511	82	18	GM552	64	36
GM512	66	34	GM553	60	40
GM514	65	35	GM554	38	62
GM515	77	23	GM555	32	68
GM516	87	13	GM556	33	67
GM517	86	14	GM558	56	44
GM517B	49	51	GM559	53	47
GM518	82	18	GM560	52	48
GM519	94	6	GM561	33	67
GM520	97	3	GM562	62	38
GM521	90	10	GM563	66	34
GM522	54	46	GM564	65	35
GM523	57	43	GM565	83	17
GM524	40	60	GM566	87	13
GM525	68	32	GM567	97	3
GM526	29	71	GM568	80	20
GM526B	39	61	GM569	92	8
GM527A	37	63	GM570A	75	25
GM527B	88	12	GM570B	77	23
GM527C	74	26	GM570C	74	26
GM528	92	8	GM571	81	19
GM528B	97	3	GM572	87	13
GM529	99	1	GM573	59	41
GM529B	99	1	GM574	66	34
GM530	53	47	GM575	59	41
GM531	95	5	GM576	70	30
GM533A	53	47	GM577	56	44
GM533B	51	49	GM578	53	47
GM533C	45	55	GM579	60	40
GM533D	44	56	GM580	63	37
GM533E	45	55	GM581	72	28
GM534A	55	45	GM582A	74	26
GM534B	36	64	GM583	70	30
GM534C	95	5	GM584	78	22
GM534X	95	5	GM585	82	18
GM535	33	67	GM586	26	74
GM535B	94	6	GM587	68	32
GM536	37	63	GM588	57	43
GM538	52	48	GM589	73	27
GM539	32	68	GM590	59	41
GM540	30	70	GM591	64	36
GM541	32	68	GM592	45	55
GM542	27	73	GM593	62	38
GM543	69	31	GM594	54	46
GM544A	28	72	GM595	91	9
GM544B	60	40	GM596	45	55
GM545A	23	77	GM597	42	58
GM545B	80	20	GM598A	36	64
GM546A	18	82	GM598B	40	60
GM546B	27	73	GM599	70	30
GM547	33	67	GM600A	73	27
GM548	31	69	GM600B	81	19

TABLE A-1 (Continued)

Sample #	Precambrian %	Carbonate %	Sample #	Precambrian %	Carbonate %
GM601	66	34	HG638B	40	60
GM602	22	78	HG639	30	70
GM605	48	52	HG640	66	34
GM606	58	42	HG641	28	72
GM607	59	41	HG642	34	66
GM608	27	73	HG643	24	76
GM609	27	73	HG644A	34	66
GM610	30	70	HG644B	75	25
GM611	19	81	HG645A	44	56
GM612	16	84	HG645B	60	40
GM613	34	66	HG646	56	44
GM614	80	20	HG648	64	36
GM617	24	76	HG650	89	11
GM624	40	60	HG651	76	24
G308A	98	2	HG652	70	30
HG600	47	53	HG653	74	26
HG601	30	70	HG653B	74	26
HG602	25	75	HG654	73	27
HG603	69	31	HG655	67	33
HG605	28	72	HG656A	68	32
HG607	87	13	HG657C	62	38
HG608	70	30	HG657D	63	37
HG608D	67	33	HG657F	59	41
HG609	28	72	HG657H	61	39
HG609B	31	69	HG658A	62	38
HG610A	59	41	HG658B	68	32
HG611	72	28	HG658D	71	29
HG611A	75	25	HG658E	57	43
HG611B	95	5	HG659A	100	-
HG612A	70	30	HG660	76	24
HG612B	74	26	HG661	48	52
HG613	38	62	HG662	66	34
HG614	40	60	HG663	37	63
HG615	46	54	HB001	79	21
HG616	87	13	HB002	68	32
HG618	96	4	HB003	58	42
HG619	96	4	HB004	64	36
HG620	91	9	HB007	42	58
HG620A	17	84	HB008	70	30
HG621	69	31	HB009	64	36
HG622	30	70	HB011	56	44
HG623	65	35	HB012	60	40
HG624	58	42	HB013	60	40
HG625	63	37	HB014	58	42
HG626	42	58	HB015	67	33
HG627	78	22	HB016A	69	31
HG628	51	49	HB016	62	38
HG629	67	33	HB017	65	35
HG630	73	27	HB018	63	37
HG631B	3	97	HB019	62	38
HG632	83	17	HB020	66	34
HG633	89	11	HB022	64	36
HG634	91	9	HB024	48	52
HG635	9	91	HB029	59	41
HG636	22	78	HB030A	8	92
HG637	81	19	HB031	75	25
HG638	55	45	HB035	33	67

TABLE A-1 (Continued)

Sample #	Precambrian %	Carbonate %	Sample #	Precambrian %	Carbonate %
HB037	78	22	HB062	73	27
HB037A	40	60	HB063	75	25
HB038	70	30	HB064	86	14
HB039	81	19	HB065	93	7
HB045	68	32	HB066	68	32
HB047	70	30	HB068	99	1
HB049	91	9	HB069	73	27
HB050	87	13	HB070	82	18
HB051	82	18	HB076A	48	52
HB052	34	66	HB076B	64	36
HB053	85	15	HB078	90	10
HB055	91	9	HB079	78	22
HB057	73	27	HB086	99	1
HB058	73	27	HB089	83	17
HB059	79	21	HB093	74	26
HB060	77	23			

APPENDIX B: DESCRIPTION OF AGGREGATE DEPOSITS

TABLE B-1
AGGREGATE DEPOSITS IN THE R.M. OF LAC DU BONNET

Deposit Number	Genetic Type	Sample Number	Per Cent Stone (+ #4) (+ 4.76 mm)	Lithology 4-16 mm % Precambrian	% Carbonate	Estimated Reserves ('000 m^3)	Comments
3801	Glaciolacustrine	—	—	—	—	36	sterilized by house
3802A	Glaciofluvial	—	—	—	—	—	extensively tested; sand
3802B	Glaciofluvial	GM614	45	80	20	985	10% depleted
		GM601	57	66	34		
3802C	Glaciofluvial	GM557	—	—	—	48	40% depleted, high water table
3802D	Glaciofluvial	—	—	—	—	27	tested by Highways
3802E	Glaciofluvial	—	—	—	—	256	35% depleted; fines to north
3802F	Glaciofluvial	—	—	—	—	—	extensively tested; sand
3803	Glaciolacustrine	GM554	26	38	62	187	10% depleted; very sandy
3804	Glaciofluvial	—	—	—	—	—	sand
3805	Glaciofluvial	—	—	—	—	—	sand
3806	Glaciofluvial	—	—	—	—	—	sand
3807A	Glaciofluvial	GM624	—	40	60	22	tested by Highways
3807B	Glaciofluvial	—	—	—	—	—	extensively tested; sand
3808A	Glaciofluvial	—	—	—	—	—	possible gravel pockets
3808B	Glaciofluvial	GM594	48	54	56	240	50% depleted, L G D. of Reynolds pit
		GM595	29	91	9		
3808C	Glaciofluvial	—	—	—	—	—	possible gravel pockets
3809A	Glaciofluvial	—	—	—	—	—	possible gravel pockets, sterilized along Hwy. and CPR
3809B	Glaciofluvial	GM551A	37	31	69		60% depleted; possibly extends to north
		GM551B	35	72	28		
3810A	Glaciofluvial	—	—	—	—	—	possible gravel pockets
3810B	Glaciofluvial	—	—	—	—	450	30% depleted; untested
3811	Glaciofluvial	—	—	—	—	—	predominantly sand
3812	Glaciofluvial	—	—	—	—	—	predominantly sand
3813	Glaciolacustrine	GM552	51	64	36	212	30% depleted
		GM617	45	24	76		
3814	Glaciolacustrine	—	—	—	—	—	sand
3815	Glaciolacustrine	—	—	—	—	—	sand
3816	Glaciofluvial	—	—	—	—	—	possible gravel pockets
3817	Glaciolacustrine	—	—	—	—	29	20% depleted
3818	Glaciolacustrine	GM542	48	27	73	11	requires testing
3819	Glaciolacustrine	GM540	21	30	70	390	20% depleted; water table at 2.5m
		GM541	12	32	68		
3820A	Glaciofluvial	—	—	—	—	—	possible gravel pockets
3820B	Glaciofluvial	—	—	—	—	—	possible gravel pockets
3821	Glaciolacustrine	GM553	35	60	40	340	25% depleted
3822	Glaciolacustrine	—	—	—	—	390	no access, requires testing
3823	Glaciofluvial	—	—	—	—	—	C F S. Beausejour, possible gravel pockets
3824	Glaciolacustrine	—	—	—	—	300	access via C F S. Beausejour road; requires testing
3825	Glaciolacustrine	—	—	—	—	84	access via C F S. Beausejour road; requires testing
3826	Glaciofluvial	—	—	—	—	—	possible gravel pockets, largely sterilized by Hwy
3827	Glaciolacustrine	—	—	—	—	134	no access; requires testing
3828	Glaciofluvial	—	—	—	—	—	C F S. Beausejour, possible gravel pockets
3829	Glaciolacustrine	—	—	—	—	188	no access; requires testing
3830	Glaciolacustrine	—	—	—	—	242	tested by Highways
3831	Glaciofluvial	—	—	—	—	—	possible gravel pockets; no access
3832	Glaciolacustrine	—	—	—	—	70	sterilized by Highway
3833	Glaciolacustrine	—	—	—	—	82	no access; requires testing
3834	Glaciolacustrine	—	—	—	—	88	no access; requires testing
3835	Glaciolacustrine	—	—	—	—	63	poor access; requires testing
3836	Glaciolacustrine	—	—	—	—	75	poor access; requires testing
3837	Glaciofluvial	—	—	—	—	—	possible gravel pockets
3838	Glaciolacustrine	—	—	—	—	70	predominantly sand
3839	Glaciolacustrine	—	—	—	—	216	no access; high water table
3840	Glaciolacustrine	—	—	—	—	7	depleted, sterilized by town of Milner Ridge
3841	Glaciofluvial	—	—	—	—	—	no access; possible gravel pockets
3842	Glaciolacustrine	—	—	—	—	97	no access; requires testing
3843A	Glaciofluvial	—	—	—	—	—	predominantly sand
3843B	Glaciofluvial	GM602	51	22	78	15	predominantly sand, reserves associated with test hole GM602
3844	Glaciolacustrine	—	—	—	—	135	5% depleted
3845	Glaciolacustrine	—	—	—	—	258	predominantly sand
3846A	Glaciofluvial	—	—	—	—	—	predominantly sand
3846B	Glaciofluvial	—	—	—	—	—	predominantly sand
3847	Glaciolacustrine	—	—	—	—	214	no access; requires testing
3848	Glaciolacustrine	GM610	48	30	70	650	extensively tested by Highways, high quality
		GM611	60	19	81		
		GM612	38	16	84		

TABLE B-1 (Continued)

Deposit Number	Genetic Type	Sample Number	Per Cent Stone (+ #4) (+ 4.76 mm)	Lithology 4-16 mm % Precambrian	Lithology 4-16 mm % Carbonate	Estimated Reserves ('000 m^3)	Comments
3849	Glaciolacustrine	GM607	36	—	—	348	25% sterilized or depleted; old Hwy. 214 built on ridge
		GM608	31	27	73		
		GM609	41	27	73		
3850	Glaciolacustrine	GM605	39	48	52	54	extensively tested by Hwys.
		GM606	50	58	42		
3851	Glaciofluvial	—	—	—	—	—	predominantly sand
3852	Glaciolacustrine	GM603	11	—	—	181	30% depleted; fines to east
3853A	Glaciolacustrine	GM548	31	31	69	360	low quality; largely sterilized by Hwy. 214.
3853B	Glaciolacustrine	GM546A	47	18	82	154	Milner Ridge pit, active, 90% depleted;
		GM546B	39	27	73	—	south portion ready for rehabilitation.
3854	Glaciolacustrine	GM547	25	33	67	492	municipal dump; sandy, fines to north; 60% depleted
3855	Glaciolacustrine	—	—	—	—	188	predominantly sand
3856	Glaciolacustrine	—	—	—	—	103	poor access; low quality
3857	Glaciofluvial	GM525	26	68	32	—	gravel pockets; poor access
		GM527A	25	40	60		
		GM527B	24	72	28		
3858	Glaciofluvial	—	—	—	—	—	poor access; possible gravel pockets
3859	Glaciofluvial	—	—	—	—	—	poor access; possible gravel pockets
3860	Glaciofluvial	—	—	—	—	—	poor access; possible gravel pockets
3861	Glaciolacustrine	—	—	—	—	45	predominantly sand
3862	Glaciolacustrine	GM559	45	53	47	199	5% depleted; extensively tested by Highways
3863	Glaciofluvial	GM533A	31	53	47	102	55% depleted
		GM533B	53	51	49		
		GM533C	45	45	55		
		GM534	39	55	45		
3864	Glaciofluvial	—	—	—	—	25	1 test hole surrounded by sand
3865A	Glaciofluvial	GM528	39	97	3	—	gravel pockets
		GM529A	42	99	1		
		GM529B	48	99	1		
		GM530	19	53	47		
		GM562	24	62	38		
3865B	Glaciofluvial	GM565	40	83	17	30	poor access; sharp ridge
		GM566	42	87	13		
3866	Glaciolacustrine	GM535	41	33	67	50	60% depleted; extensively tested by Highways
		GM560	32	52	48		
3867	Glaciolacustrine	GM524	35	40	60	91	30% depleted; extensively tested by Highways
3868	Glaciolacustrine	GM563	40	66	34	30	sharp ridge
		GM564	33	65	35		
3869	Glaciolacustrine	—	—	—	—	8	60% depleted; low quality
3870	Glaciolacustrine	—	—	—	—	26	30% depleted; low quality
3871	Glaciolacustrine	GM538	15	52	48	16	30% depleted; low quality
3872	Glaciolacustrine	—	—	—	—	256	predominantly sand
3873	Glaciolacustrine	GM511	58	81	19	235	30% depleted; north end sterilized by houses
3874	Glaciolacustrine	—	—	—	—	318	predominantly sand
3875	Glaciolacustrine	—	—	—	—	156	predominantly sand
3876A	Glaciolacustrine	GM512	31	62	38	410	20% depleted
3876B	Glaciolacustrine	—	—	—	—	30	poor access
3876C	Glaciolacustrine	GM590	43	59	41	183	poor access
		GM591	18	64	36		
		GM592	38	45	55		
		GM593	52	62	38		
3876D	Glaciolacustrine	GM578	25	53	47	175	poor access
		GM579	35	60	40		
		GM580	28	63	37		
3877A	Glaciolacustrine	—	—	—	—	64	extensively tested by Hwys.
3877B	Glaciolacustrine	GM574	14	66	34	14	extensively tested by Hwys; poor access
3878	Glaciofluvial	—	—	—	—	—	predominantly sand
3879	Glaciofluvial	GM514	19	60	40	72	25% depleted
		GM573	32	59	41		
3880A	Glaciofluvial	—	—	—	—	—	extensively tested; predominantly sand
3880B	Glaciofluvial	—	—	—	—	—	extensively tested; predominantly sand
3880C	Glaciofluvial	GM569	37	92	8	177	extensively tested by Hwys.
3880D	Glaciofluvial	GM515	41	72	28	184	20% depleted; extensively tested
3880E	Glaciofluvial	GM517	35	83	17	10	80% depleted; garbage dump
3880F	Glaciofluvial	GM516	35	87	13	96	60% depleted; fines to west
		GM572	22	87	13		
3880G	Glaciofluvial	GM519	25	95	5	50	5% depleted; many boulders
3880H	Glaciofluvial	GM518	26	81	19	310	50% depleted; fire lookout at north end
		GM520	53	98	2		
		GM521	33	90	10		

TABLE B-1 (Continued)

Deposit Number	Genetic Type	Sample Number	Per Cent Stone (+ #4) (+ 4.76 mm)	Lithology 4-16 mm % Precambrian	Lithology 4-16 mm % Carbonate	Estimated Reserves ('000 m^3)	Comments
3880I	Glaciofluvial	—	—	—	—	230	requires testing
3881	Glaciolacustrine	—	—	—	—	61	no access; requires testing
3882A	Glaciolacustrine	—	—	—	—	81	no access; requires testing
3882B	Glaciolacustrine	GM575	41	59	41	18	poor access
3883A	Glaciolacustrine	—	—	—	—	112	no access; requires testing
3883B	Glaciolacustrine	—	—	—	—	33	no access; requires testing
3883C	Glaciolacustrine	GM571	48	81	19	180	extensively tested by Hwys
3884	Glaciolacustrine	GM576	32	70	30	36	poor access; sandy
3885	Glaciolacustrine	GM577	12	56	54	45	poor access; sandy
3886	Glaciofluvial	—	—	—	—	—	extensively tested; predominantly sand
3887	Glaciolacustrine	—	—	—	—	350	no access; requires testing
3888	Glaciolacustrine	—	—	—	—	73	no access; requires testing
3889	Glaciolacustrine	—	—	—	—	58	no access; requires testing
3890	Glaciolacustrine	—	—	—	—	45	no access; requires testing
3891	Glaciolacustrine	—	—	—	—	106	poor access; requires testing
3892	Glaciolacustrine	GM567	27	97	3	20	poor access
3893	Glaciolacustrine	GM583	11	70	30	40	poor access; extensively tested
		GM584	81	78	22		
3894	Glaciolacustrine	GM513	—	—	—	134	extensively tested
		GM585	33	82	18		
3895	Glaciolacustrine	—	—	—	—	185	no access; requires testing
3896A	Glaciolacustrine	GM522	27	48	52	235	40% depleted; high water table
3896B	Glaciolacustrine	GM523	41	58	42	125	40% depleted; high water table
3896C	Glaciolacustrine	—	—	—	—	103	no access; high water table
3896D	Glaciolacustrine	—	—	—	—	220	no access; high water table
3897	Glaciofluvial	—	—	—	—	315	45% depleted; sandy areas
TOTAL RESERVES						14 674	

TABLE B-2

AGGREGATE DEPOSITS IN THE L.G.D. of ALEXANDER

Deposit Number	Genetic Type	Sample Number	Per Cent Stone (+ #4) (+ 4.75 mm)	Lithology 4-16 mm % Precambrian	% Carbonate	Estimated Reserves ('000 m^3)	Comments
4401	Glaciolacustrine	HG602	10	25	75	52	very sandy deposit
4402	Glaciolacustrine	—	—	—	—	23	
4403	Glaciolacustrine	HG605	60	28	72	21	1 pit, intermittent usage
4404	Glaciolacustrine	HB024	44	48	52	60	1.5 m gravel overlying sand
4405	Glaciofluvial	—	—	—	—	76	tested by Highways
4406	Glaciolacustrine	HG636	45	22	78	61	garbage dump
4407	Glaciofluvial	HG616	33	87	13	34	1 pit, intermittent usage
4408	Glaciolacustrine	HG614	30	40	60	64	deposit shallow and sandy; 1 active pit near depletion
		HG613	39	38	62		
4409	Glaciolacustrine	—	—	—	—	40	1 m gravel over sand
4410	Glaciofluvial	HG611A	29	75	25	826	deposit sandy to east; several pits used on intermittent basis
		HG611B	35	95	10		
		HG612A	38	70	30		
		HG612B	23	74	26		
		HG637	35	81	19		
		HB078	46	90	10		
		HB079	35	78	22		
4411	Glaciofluvial	HB086	—	99	1	14	1 m pebble gravel over sand
4412	Glaciofluvial	—	—	—	—	51	tested by Highways
4413	Glaciofluvial	HG608	24	70	30	113	1 active pit
		HB022	21	64	36		
4414	Glaciofluvial	HG620	19	91	9	24	1 pit, near depletion
4415	Glaciolacustrine	HG607	50	87	13	2371	deposit extremely coarse in north, finer to south;
	overlying	HG621	47	69	31		several pits used on intermittent basis
	glaciofluvial	HG622	1	30	70		
		HG623	63	65	35		
		HB001	46	79	21		
		HB002	52	68	32		
		HB003	39	58	42		
		HB004	54	64	36		
		HB006	67	64	36		
		HB008	51	70	36		
		HB010	22	56	44		
		HB012	28	60	40		
		HB013	56	60	40		
		HB015	23	67	33		
		HB016A	28	62	38		
		HB016B	76	69	31		
		HB017	59	65	35		
		HB018	51	63	37		
		HB019	71	62	38		
		HB020	57	66	34		
4416	Glaciolacustrine	HG624	45	58	42	78	1 pit, intermittent usage
		HB014	25	58	42		
4417	Glaciofluvial	HG619	32	96	4	58	1 pit, revegetated
4418	Glaciofluvial	HG618	11	96	4	98	3 revegetated pits
		HB089	49	83	17		
4419	Glaciofluvial	—	—	—	—		
4420	Glaciofluvial	HB093	12	74	26	29	
4421	Glaciofluvial	HG627	57	78	22	(684)	in Grand Beach Park
4422	Glaciolacustrine	—	—	—	—	(33)	in Grand Beach Park
4423	Glaciolacustrine	HG660	62	76	24	(18)	in Grand Beach Park
4424	Glaciolacustrine	—	—	—	—	54	deposit sterilized by subdivisions
4425	Glaciolacustre	—	—	—	—		
4426	Glaciolacustrine	HG662	50	66	34	25	1 revegetated pit
4427	Glaciofluvial	HG628	53	51	49	372	1 active pit
4428	Glaciofluvial	—	—	—	—	25	deposit near depletion
4429	Glaciolacustrine	—	—	—	—		
4431	Glaciofluvial	HB070	31	82	18	183	
4432	Glaciofluvial	—	—	—	—	—	
4433	Glaciofluvial	HG634	25	91	9	238	no open pits
		HB063	34	75	25		
		HB064	35	86	14		
4435	Glaciofluvial	HG630	44	73	27	3642	deposit is 8 m deep in north central portion; less than 3 m along
		HG632	47	83	17		western edge
		HG633	39	89	11		
		HB037	57	78	22		
		HB038	35	70	30		
		HB039	662	81	19		

TABLE B-2 (Continued)

Deposit Number	Genetic Type	Sample Number	Per Cent Stone (+ #4) (+ 4.76 mm)	Lithology 4-16 mm % Precambrian	% Carbonate	Estimated Reserves ('000 m^3)	Comments
		HB044	70	73	27		
		HB045	48	68	32		
		HB046	57	69	31		
		HB047	54	70	30		
		HB049	40	91	9		
		HB050	37	87	13		
		HB051	47	82	18		
		HB053	35	85	15		
		HB058	48	73	27		
		HB059	47	79	21		
		HB069	28	77	23		
4437	Glaciofluvial	—	—	—	—		
4441	Glaciolacustrine	—	—	—	—	211	no access
4442	Glaciolacustrine	—	—	—	—	52	sterilized by farmstead and PR304
4443	Glaciolacustrine	—	—	—	—	53	1 m of sandy pebble gravel
4444	Glaciolacustrine	—	—	—	—	60	not tested
4445	Glaciofluvial	HG640	38	66	34	8	1 revegetated pit, near depletion
4446	Glaciolacustrine	—	—	—	—	61	very sandy deposit
4447	Glaciolacustrine	HG643	54	24	76	24	shallow deposit; 1 revegetated pit
4448	Glaciolacustrine	HG609A	33	28	72	47	sandy deposit; 1 pit intermittent usage
		HG609B	25	31	69		
4449	Glaciofluvial	HG659C	51	100	—	13	pit near depletion
4450	Glaciofluvial	GM509	44	85	15	61	1 pit intermittent usage, 1 pit revegetated
		GM510	44	75	25		
4451	Glaciofluvial	GM507	30	90	10	59	1 pit intermittent usage, 1 pit revegetated
		GM508	54	90	10		
4452	Glaciofluvial	—	—	—	—	197	north end of Gull Lake deposits
4453	Glaciofluvial	—	—	—	—	38	winter access only
4454	Glaciofluvial	—	—	—	—	24	1 pit
	TOTAL RESERVES					9828	

( ) not included in total reserves as they are sterilized by provincial park

TABLE B-3

AGGREGATE DEPOSITS IN THE R.M. OF ST. CLEMENTS (eastern portion)

Deposit Number	Genetic Type	Sample Number	Per Cent Stone (+ #4) (+ 4.76 mm)	Lithology 4-16 mm % Precambrian	% Carbonate	Estimated Reserves ('000 m^3)	Comments
4013	Glaciofluvial	—	—	—	—	20	
4014	Glaciofluvial	—	—	—	—	433	untested
4015	Glaciofluvial	HG625	35	63	37	520	1 inactive pit; 1 revegetated pit
		HG661	52	48	52		
4016	Glaciofluvial	—	—	—	—	45	revegetated pits
4017	Glaciolacustrine overlying glacio fluvial	HG629	65	67	33	727	1 active pit; 2 revegetated pits
		HG638A	43	55	45		
		HG638B	39	40	60		
4018	Glaciolacustrine	—	—	—	—	64	untested
4019	Glaciolacustrine	HG639	63	30	70	452	2 large pits; intermittent usage; deposit sandier at west end
		HG663	26	37	63		
4020	Glaciofluvial	HG651	28	76	24	7 029	Gull Lake deposit; extensively mined; 20 m gravel in north, deposit sandier and shallow to south
		HG652	53	70	30		
		HG653A	38	74	26		
		HG653B	1	74	26		
		HG654	52	73	27		
		HG655	52	67	33		
		HG658A	61	62	38		
		HG658B	69	68	32		
		HG658D	55	71	29		
		HG658E	83	57	43		
		HB029	35	59	41		
4021	Glaciolacustrine overlying glacio-fluvial	HG644A	44	34	66	45	pit near depletion
		HG644B	30	75	25		
4022	Glaciolacustrine	HG648	32	64	36	110	deposit depleted in south
4023	Glaciofluvial	HG656	42	68	32	204	1 extensive pit; inactive
4024	Glaciolacustrine	—	—	—	—		
4025	Glaciolacustrine	—	—	—	—	129	tested by Highways
4026	Glaciofluvial	HG657C	36	62	38	545	1 active pit
		HG657D	49	63	37		
4027	Glaciolacustrine	HG645	8	44	56	103	1 revegetated pit
	TOTAL RESERVES					10 481	

APPENDIX C: GRAIN SIZE DATA OF AGGREGATE DEPOSITS

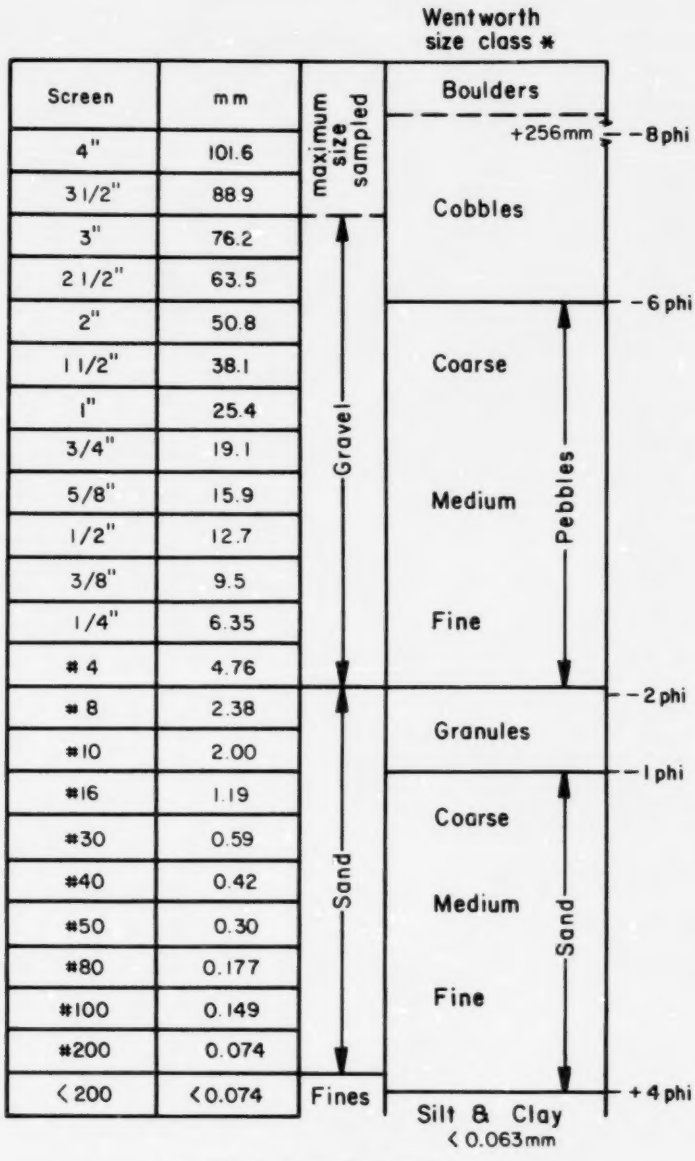


FIGURE C-1 Grain size classification.

TABLE C-1

GRAIN SIZE DISTRIBUTION OF AGGREGATE SAMPLES IN THE R.M. OF LAC DU BONNET

Deposit Number	Sample Number	% Pebbles 4-64 mm	% Granules 2-4 mm	% Sand 0.6-2 mm	% Silt & Clay -0.6 mm	Crushable on site
3802B	GM601	57.3	13.9	27.5	1.3	X
	GM614	45.3	11.1	42.1	1.5	X
3803	GM554	26.4	9.9	61.5	2.2	X
3807A	GM624	52.3	13.6	32.0	2.1	X
3808B	GM594	47.7	8.5	41.4	2.4	X
	GM595	28.6	15.5	53.9	2.0	X
3809B	GM551A	37.4	16.8	43.4	2.4	X
	GM551B	34.5	12.4	50.0	3.1	X
3813	GM552	51.0	24.8	22.7	1.5	X
	GM617	44.7	12.9	40.4	2.0	X
3818	GM542	48.5	10.7	39.3	1.5	X
3819	GM540	21.4	15.1	62.1	1.4	X
	GM541	12.1	21.2	64.5	2.2	X
3821	GM553	34.8	27.8	36.0	1.4	X
3843B	GM602	51.3	20.3	26.1	2.3	X
3848	GM610	48.2	13.7	35.2	2.9	X
	GM611	60.1	13.9	24.5	1.5	X
	GM612	38.1	11.9	48.6	1.4	X
3849	GM607	36.0	13.6	49.6	0.8	X
	GM608	30.7	18.5	49.7	1.1	X
	GM609	40.7	19.7	38.1	1.5	X
3850	GM605	38.6	10.3	48.1	3.0	X
	GM606	48.8	12.7	35.6	2.9	X
3852	GM603	11.3	5.1	81.3	2.4	X
3853A	GM548	31.5	13.1	54.8	0.6	X
3853B	GM546A	46.8	13.2	39.2	0.8	X
	GM546B	39.3	15.3	45.1	0.3	X
3854	GM547	25.3	12.6	61.2	0.9	X
3857	GM525	26.3	10.1	61.6	2.0	X
	GM527A	24.5	12.2	61.2	2.1	X
	GM527C	23.8	7.1	59.6	9.5	X
3862	GM559	44.7	7.4	47.1	0.8	X
3863	GM533A	30.5	11.3	57.1	1.1	X
	GM533B	53.5	13.2	32.3	1.0	X
	GM533C	45.5	6.6	46.7	1.2	X
	GM534	38.5	12.3	48.0	1.2	X
3865A	GM528	39.1	11.2	47.6	2.1	X
	GM529A	42.1	12.2	44.1	1.6	X
	GM529B	47.5	7.4	40.7	4.4	X
	GM530	18.9	13.7	64.4	3.0	X
	GM562	23.9	24.1	49.3	2.7	X
3865B	GM565	46.2	15.9	35.4	2.5	X
	GM566	42.2	12.3	42.0	3.5	X
3866	GM535	41.5	15.0	42.7	0.8	X
	GM560	32.0	33.1	34.1	0.8	X
3867	GM524	35.2	13.0	50.9	0.9	X
3868	GM563	39.7	18.9	37.4	4.0	X
	GM564	33.1	25.9	39.0	2.0	X
3871	GM538	15.1	17.7	65.6	1.6	X
3873	GM511	58.4	5.4	35.2	1.0	X
3876A	GM512	31.4	20.9	45.2	2.5	X
3876C	GM590	43.1	17.3	38.1	1.5	X
	GM591	17.9	24.3	55.3	2.5	X
	GM592	38.1	17.4	39.2	5.3	X
	GM593	51.6	20.6	25.0	2.8	X

TABLE C-1 (Continued)

Deposit Number	Sample Number	% Pebbles 4-64 mm	% Granules 2-4 mm	% Sand 0.6-2 mm	% Silt & Clay -0.6 mm	Crushable on site 15 cm X Yes
3876D	GM578	25.0	14.0	59.5	1.5	X
	GM579	35.5	13.4	48.9	2.2	X
	GM580	28.1	16.0	54.5	1.4	X
3877B	GM574	14.5	12.4	70.0	3.1	X
3879	GM514	19.5	20.4	57.6	2.5	X
	GM573	32.1	11.7	54.3	1.9	X
3880C	GM569	37.4	34.8	26.2	1.6	X
3880D	GM515	40.9	14.7	43.1	1.3	X
3880E	GM517	38.3	9.4	50.7	1.6	X
3880F	GM516	34.9	5.4	58.2	1.5	X
	GM572	21.8	11.9	64.6	1.7	X
3880G	GM519	25.5	25.3	46.5	2.7	X
3880H	GM518	25.5	10.5	63.4	0.6	X
	GM520	53.5	14.7	30.0	1.8	X
	GM521	33.3	8.8	56.7	1.2	X
3882B	GM575	41.3	29.9	26.4	2.4	X
3883C	GM571	48.1	10.3	40.7	0.9	X
3884	GM576	31.7	14.9	51.6	1.8	X
3885	GM577	11.5	18.8	68.2	1.5	X
3892	GM567	26.5	31.7	39.3	2.5	X
3893	GM583	10.9	64.0	23.8	1.3	X
	GM584	80.6	3.0	15.4	1.0	X
3894	GM585	32.9	18.8	46.7	1.6	X
3896A	GM522	27.2	10.0	61.7	1.1	X
3896B	GM523	40.7	12.9	44.8	1.6	X

TABLE C-2

GRAIN SIZE DISTRIBUTION OF AGGREGATE SAMPLES IN THE L.G.D. OF ALEXANDER

Deposit Number	Sample Number	% Pebbles 4-64 mm	% Granules 2-4 mm	% Sand 0.6-2 mm	% Silt & Clay -0.6 mm	Crushable on site 15 cm X Yes
4401	HG602	9.5	5.6	82.8	2.1	X
4403	HG605	59.8	7.2	32.0	1.0	X
4404	HB024	43.8	11.4	41.7	3.1	X
4406	HG636	44.7	11.8	41.1	2.4	X
4407	HG616	33.2	8.0	57.3	1.5	X
4408	HG614	29.3	14.6	55.4	0.7	
	HG613	38.5	15.8	40.4	5.3	X
4409	HG615	33.0	5.1	60.9	1.0	X
4410	HG611A	29.0	21.2	48.7	1.1	
	HG611B	35.4	9.6	53.5	1.5	X
	HG612A	38.3	10.9	49.3	1.5	X
	HG612B	22.7	30.0	46.7	0.6	X
	HG637	34.7	15.3	47.6	2.4	X
	HB078	45.9	21.2	32.1	0.8	
	HB079	34.7	15.7	48.5	1.1	
4413	HG608	23.9	11.5	62.5	2.1	X
	HB022	20.8	9.0	68.0	2.2	X
4414	HG620	18.7	12.7	62.9	5.7	X
4415	HG607	50.3	6.6	41.7	1.4	X
	HG621	46.7	17.2	34.2	1.9	X
	HG622	1.4	3.8	93.6	1.2	X
	HG623	63.4	11.8	23.8	1.0	
	HB001	46.3	5.1	47.0	1.6	X
	HB002	52.3	7.4	39.1	1.2	X
	HB003	38.6	15.0	45.3	1.1	
	HB004	53.9	12.8	32.8	0.5	X
	HB006	66.9	14.1	17.0	2.0	
	HB008	51.4	14.6	32.0	2.0	X
	HB010	21.7	13.9	63.4	1.0	
	HB012	28.0	14.9	55.1	2.0	
	HB013	56.1	8.6	34.3	1.0	
	HB015	23.4	7.5	64.9	4.2	X
	HB016A	27.5	19.0	52.7	0.8	
	HB016B	76.0	4.1	17.4	2.5	
	HB017	59.1	20.6	19.2	1.1	
	HB018	51.2	19.1	28.6	1.1	
	HB019	70.5	17.3	11.4	0.8	X
	HB020	56.7	10.7	30.6	2.0	
4416	HG624	45.2	15.4	39.0	0.4	
	HB014	25.1	19.3	54.4	1.2	
4417	HG619	32.1	30.8	34.4	2.7	X
4418	HG618	11.0	7.8	80.3	0.9	X
	HB089	49.2	9.1	41.3	0.4	
4420	HB093	11.9	16.1	71.3	0.7	
4421	HG627	57.4	7.0	35.4	0.2	X
4423	HG660	62.4	11.7	25.1	0.8	X
4426	HG662	50.1	5.6	41.2	3.1	
4427	HG628	53.5	9.4	36.6	0.5	X
4431	HB070	30.9	11.5	56.7	0.9	
4433	HG634	24.5	14.2	56.8	4.5	X
	HB063	33.8	11.6	53.7	0.9	
	HB064	35.3	9.9	52.7	2.1	X

TABLE C-2 (Continued)

Deposit Number	Sample Number	% Pebbles 4-64 mm	% Granules 2-4 mm	% Sand 0.6-2 mm	% Silt & Clay -0.6 mm	Crushable on site 15 cm X Yes
4435	HG630	43.7	17.5	36.6	2.2	X
	HG632	47.4	14.1	37.1	1.4	X
	HG633	38.8	26.3	32.5	2.4	X
	HB037	57.4	3.6	38.0	1.0	X
	HB038	34.9	25.2	38.4	1.5	
	HB039	62.1	3.7	33.8	0.4	
	HB044	69.9	12.5	16.3	1.3	
	HB045	48.4	20.6	29.8	1.2	
	HB046	56.7	10.7	31.3	1.3	X
	HB047	53.8	13.1	30.5	2.6	X
	HB049	39.9	12.6	44.9	2.6	X
	HB050	36.8	15.5	46.5	1.2	X
	HB051	47.2	8.7	43.0	1.1	X
	HB053	35.4	12.9	49.9	1.8	
	HB058	48.3	17.9	33.4	0.4	
	HB059	46.7	13.6	38.5	1.2	
4435	HB060	27.5	12.8	58.9	0.8	X
4445	HG640	37.7	9.0	48.1	5.2	X
4447	HG643	53.7	9.8	33.3	3.2	X
4448	HG609A	33.1	20.9	45.2	0.8	X
	HG609B	25.2	22.9	51.2	0.7	
4449	HG659C	50.9	25.1	22.8	1.2	X
4450	GM509	43.6	11.3	43.1	2.0	X
	GM510	44.2	13.4	41.4	1.0	X
4451	GM507	30.2	15.6	46.1	8.1	X
	GM508	54.4	7.7	34.0	3.9	

TABLE C-3

GRAIN SIZE DISTRIBUTIONS OF AGGREGATE SAMPLES IN THE R.M. OF ST. CLEMENTS

Deposit Number	Sample Number	% Pebbles 4-64 mm	% Granules 2-4 mm	% Sand 0.6-2 mm	% Silt & Clay -0.6 mm	Crushable on site 15 cm X Yes
4015	HG625	35.0	22.4	42.2	0.4	
	HG661	52.5	20.2	24.0	3.3	X
4017	HG629	65.0	9.7	22.9	2.4	X
	HG638A	43.0	6.5	48.1	2.4	X
	HG638B	39.1	10.7	48.2	2.0	X
4019	HG639A	62.8	7.2	28.6	1.4	X
	HG663	25.5	11.1	62.6	0.8	X
4020	HG651	28.4	11.9	55.8	3.9	X
	HG652	53.4	13.8	28.2	4.6	X
	HG653A	37.9	12.7	44.5	4.9	X
	HG653B	1.0	5.7	91.8	1.5	
	HG654	51.9	8.2	37.2	2.7	X
	HG655	51.5	9.8	35.4	3.3	X
	HG658A	60.8	14.2	23.7	1.3	X
	HG658B	69.4	13.4	16.7	0.5	X
	HG658D	55.3	17.1	22.1	5.5	X
	HG658E	83.4	7.7	7.9	1.0	X
	HB029	34.9	14.1	48.4	2.6	X
4021	HG644A	44.1	8.3	46.6	1.0	X
	HG644B	29.9	9.0	56.8	4.3	X
4022	HG648	31.8	7.1	56.1	5.0	
4023	HG656	41.8	10.2	46.2	1.8	
4026	HG657C	36.0	16.9	44.3	2.8	X
	HG657D	48.8	20.7	29.9	0.6	X
4027	HG645	8.1	14.2	76.2	1.5	

APPENDIX D: EXAMPLE OF COMPUTER PRINTOUT INFORMATION

DEPOSIT 003802B **SUBAQUEOUS OUTWASH**

TOWN	RANGE	SECTION	QUARTER		
013	09E	02	SE	315,900 CU.M.	35100 CU.M.DEPL/NOT AVAIL
			SW	344,250 CU.M.	60540 CU.M.DEPL/NOT AVAIL
		03	SE	393,000 CU.M	CU.M.DEPL/NOT AVAIL
	DEPOSIT RESERVES			1,053,150 CU.M.	

DEPOSIT #	1/4	SECT	TOWN	RANGE	OWNERSHIP
003802B	SE	02	013	09E	CROWN(PROVINCIAL)/CROWN
003802B	SW	02	013	09E	CROWN(PROVINCIAL)/CROWN
003802B	SE	03	013	09E	CROWN(PROVINCIAL)/CROWN

EXPOSURE GM614 (003802B 013 09E 02 SE) VISITED 83092

BACKHOE TEST PIT FOREST, NATURAL

5.0 M. MEDIUM HIGH- QULAITY COBBLY COARSE PEBBLE GRAVEL

SECTION A GEOLOGIST GM SECTION HEIGHT 5.0 M. EXAMINED 5.0 M.

BASE GRAVEL WATER TABLE .0 M.

LITHOLOGY 85% GENERAL PRECAMBRIANS 15% GENERAL CARBONATES

DELETERIOUS WEATHERED PEBBLES

SAMPLE — COBBLES % PEBBLES 45.29% GRANULES 11.09% SAND 42.06% SILT/CLAY 1.56%

APPENDIX D: EXAMPLE OF COMPUTER PRINTOUT INFORMATION (Continued)

SAMPLE IDENTIFICATION 003802B 013-09E-02SE GM614A

AVAILABILITY OF CRUSHABLE MATERIAL ON SITE — YES

WEIGHT OF SAND 11682.20 GMS WASHED SAMPLE — WEIGHT BEFORE 717.00 AFTER 700.90 % LOSS 2.25

SIEVE SIZE	FINE FRACTION (GMS.)	SIEVE WEIGHTS (GMS.)	PERCENT	PERCENT PASSING	PERCENT RETAINED
4 IN		0.0		100.00	0.0
3 1/2 IN		0.0	0.0	100.00	0.0
3 IN		0.0	0.0	100.00	0.0
2 1/2 IN		0.0	0.0	100.00	0.0
2 IN		1566.00	9.30	90.70	9.30
11/2 IN		1350.10	8.02	82.68	17.32
1 IN		1451.00	8.62	74.06	25.94
3/4 IN		785.40	4.67	69.39	30.61
5/8 IN	13.20	215.07	1.28	68 12	31.88
1/2 IN	31.30	509.98	3.03	65.09	34.91
3/8 IN	37.20	606.10	3.60	61.49	38.51
1/4 IN	40.60	661.50	3.93	57.56	42.44
#4	29.40	479.02	2.85	54.71	45.29
#8	86.70	1412.62	8.39	46.32	53.68
#10	27.90	454.58	2.70	43.62	56.38
#16	92.30	1503.86	8.93	34.69	65.21
#30	171.80	2799.16	16.63	18.06	81.94
#40	69.90	1138.89	6.77	11.29	88.71
#50	51.00	830.95	4.94	6.36	93.64
#80	28.00	456.21	2.71	3.65	96.35
#100	10.60	172.71	1.03	2.62	97.38
#200	11.00	179.22	1.06	1.56	98.44
<200 + W	16.10	262.32	1.56	0.0	100.00
TOTALS	717.00	16834.66			

SPLITTING FACTOR 16.29

FINENESS MODULUS 5.24

% COBBLES 0.0 % PEBBLES 45.29 % GRANULES 11.09 % SAND 42.06 % SILT/CLAY 1.56

MAPS
NOT
FILMED

CARTES
OMISES